Popular Astronomy.

Vol. XXIII, No. 2. FEBRUARY, 1915. Whole No. 222

LONGITUDE OF THE DRAKE UNIVERSITY OBSERVATORY, BY WIRELESS.

D. W. MOREHOUSE.

The difference of longitude between two stations is the difference of their local times at the same instant. Thus the problem of determining longitude resolves itself into two parts; (1) the determination of the exact local time by direct observation of the stars, at the two stations whose difference of longitude is sought, and (2) the difference of these local times at the same instant.

Another way of stating the problem would be to find the time required for the earth to turn sufficiently to bring the meridian of the western station into the position held by the eastern station; or what is the same thing, the time it takes a star in its diurnal motion to go from the eastern station to the western station.

Now the easiest way to determine this quantity is to have a signal sent with infinite speed from one observer to the other and the local time noted by each. Then the difference of these local times is the difference of longitude. The velocity of a wireless signal is the same as that of light, 186,000 miles per second, which is the nearest to an infinite speed that we are, at present, able to command.

During the winter of 1913-14 the Naval Observatory at Washington sent out a series of wireless signals to be utilized by the American Observatories, in general, and the Paris Observatory, in particular, in the determination of longitude. The plan was as follows; at 7hr. 44m. P.M. Eastern Standard Time, wireless signals one half second long and a second apart were sent for seven minutes, thus making 420 signals in a set. After an interval of two minutes a second set was sent in exactly the same manner as the first. After a thirteen minute interval a third set was sent. The regular schedule was as follows:

Washington sends from 7-44-00 to 7-51-00) Eastern Standard Time
" " " 7-53-00 to 8-00-00) " " "
" " " 8-13-00 to 8-20-00) " " "

In order that the observer might be able to identify any particular signal in any set, the signals were numbered 1, 2, 3, 4, ---- to 420. Since it was necessary to keep count of the minutes also, the first signal of each minute, after the first, in each set was omitted; thus the 60th, 120th, 180th, 240th, 300th, 360th were omitted, but the 420th was not.

The method of observing the exact instant, on the local or home clock, when any one of these signals was received is next to be considered. The "Method of Coincidences" was naturally chosen. That is, the observer was to have his receiving station and clock so arranged that the tick of his own clock and the tick of the Washington clock (over the wireless) could be heard in the same telephone receiver. This was accomplished at the Drake Observatory by connecting one pole of the break-circuit chronometer, or clock, to ground, and the other pole to a small aerial, thus making a miniature sending station of the clock.

If the beats of the Washington clock and home clock were of exactly the same length, and if they were out of step, or not beating together at the beginning of the signals, they would remain out of step, that is, the ticks would not coincide during the whole time of transmission of the signals. But if one of the clocks should gain on the other by having its ticks less than a second long, say .99 sec. then there would be some instant during the sending of the signals when the two clocks would beat together. For this reason, then, the Washington sending clock was made to send out a signal every .99 sec. approximately. We cannot call the ticks of the Washington clock seconds since they are too short, so we will call them Radio Seconds for the purpose of distinguishing them from a true second. Furthermore, it is evident that the exact length of this radio second will depend upon the rate of the home clocks of the various observers, and will have to be determined for each set, or consecutive sets, of signals. It was found that the Washington sending clock gained one beat (Radio Second) on a mean time clock in about 120 seconds; and on a sidereal clock in 143 seconds. To determine this interval accurately, it was necessary for the observer to listen to the Washington clock and the home clock simultaneously, and note the instant on the home clock when a coincidence occurred. He would continue to listen to the two clocks as they separated, the Washington clock gaining on the home clock, until another coincidence occurred, again noting the exact instant on the home clock. In this manner he would observe as many coincidences as possible in any one set of signals. With this data the average value of a Radio Second for any given set could be calculated. In order to identify this signal at the sending station, it was necessary to know the number of the signal, which was in coincidence with the home clock. This could be found by noting the interval between the coincidence and some known signal in the set.

The writer made use of a chronograph upon which the home clock automatically recorded its seconds. By means of an electric key, the instant a coincidence occurred, or a known signal was noted, it could be recorded on the chronograph. It was my habit to note as many coincidences in each set as possible and to record the first signal of each minute, that is, the first signal after an interruption. If we take as an example of one night's observation the data recorded on Friday March 13, 1914, the method will be made very plain. The headings of the different columns are self explanatory. It will be noted that the first two minutes in the first set were not observed. Reference to the column headed "Coincidences" will show that a coincidence occurred at 5h 53m 36.0s. The column "1st Signal after Interruption" shows that the 121st signal was noted at 5h 53m 57.15s, which is 21s after the coincidence. Therefore the Radio Number of the coincident signal must have been 100. Likewise a coincidence occurred at 5h 55m 59.0s which is 3 seconds after the 241st signal was noted, hence its radio number must be 244; a third coincidence occurred at 5h 58m 32.0s or 27 seconds after the 361st signal, which would make its radio number 388. Subtracting the time of the first coincidence from the time of the second coincidence we see there is an interval of 143 seconds. Since the Washington clock gained on the home clock, the Washington clock must have made 144 beats or Radio Seconds in this interval.

Likewise, between the second and third coincidences, there is an interval of 143 seconds on the home clock and hence there must have been 144 Radio Seconds on the Washington clock. The mean interval for a coincidence in this set is evidently 143 seconds and the mean value of a Radio Second on the home clock is 143/144 seconds or .993055 of a sec. Assuming that the 100th signal was in perfect coincidence with the home clock at 5h 53m 36.0s, the time of the first signal may be computed as follows; between the first and 100th signals there must have been 99 Radio Seconds and since each radio second is .993055 sec. long, the first signal must have been sent and received .993055×99 sec. earlier than the 100th signal or at 5h 53m 36.0s − (.993055×99) = 5h 51m 57.688s. Again, assuming that the 244th signal was in perfect coincidence with the home clock at 5h 55m 59.0s, the time of the first signal must have been 243 Radio seconds earlier, that is, at 5h 55m 59.0s − (.993055 × 243) = 5h 51m 57.687s. Using the third coincidence we have the time of the first signal at 5h 58m 32.0s − (.993055 × 387) = 5h 51m 57.687s. Thus all three coincidences give the same time for the first signal, to one-thousandth of a second (.001s). In the same manner we find the time of the last or 420th signal in this set, e.g., from the first coincidence to the last (420) signal

there are 320 Radio Seconds, hence 5h 53m 36.0s + (.993055 × 320) = 5h 58m 53.778s. Using the second coincidence we have 5h 55m 59.0s + (.993055 × 176) = 5h 58m 53.778s and from the third coincidence 5h 58m 32.0s + (.993055 × 32) = 5h 58m 53.778s, all of which are in perfect agreement.

In the second set, only one coincidence was observed on this evening, but since the Washington clock continued to run during the intervals between sets, we can utilize the coincidences in the first set to find the value of the Radio Second in the second set. Reference to the scheduled results shows that a coincidence occurred in the second set at 6h 5m 30.0s, and that the 301st signal was recorded at 6h 5m 56.95s, which is 27 seconds later than the coincidence, hence the coincident signal must have been the 274th. From 6h 5m 30.0s to 5h 53m 36.0s, the time of the first coincidence in the first set, there are 714 seconds. Dividing this by 143, as a trial divisor, we see that there must have been 5 coincidences between the first coincidence in the first set and the coincidence in the second set. Dividing 714 by 5, to find the exact interval we get 142.8s, which agrees very well with the value found in the first set. The value of a Radio Second, on the home clock, from this observation would be 714/719 or .993045 of a second, which is in close agreement with the value from the first set. We can now determine the time of the first and last signals in the second set, precisely as we did in the first set. We find them to be 6h 0m 58.895s and 6h 7m 54.986s respectively.

We must next consider the correction to be applied to the home clock so that we will have exact local time. This is accomplished by the ordinary method of star transits. The theory of the transit instrument gives us an equation of the following form to be solved:

$$d\theta = d\theta_i - aA_i - bB_i \pm cC_i;$$

Where $i = 1, 2, 3, 4, - - - - n$, and $d\theta_i$ = the observed corrections by the stars; a, b, c, constants of the instruments; A_i, B_i, and C_i, constants of the stars depending upon the location of the observer, and finally $d\theta$, the true correction to be derived from the observation of (n) stars. As there are usually more equations, formed from the number of stars observed, than there are unknowns in our equations to be solved, the method of Least Squares is generally adopted. The results of the time observations on Friday, March 13, are scheduled with the radio observations for the same night. The adopted correction for this night is $d\theta = +38.48$s. That is, the home clock was found to be 38.48 seconds too slow, so that this quantity must be added to the computed times, as determined above, of the first and last signals in each set. We are now able to give the exact

local time, when any one of the above signals was received at Des Moines. Subtracting this time from the exact local time at Washington when the signal was sent (assuming that the time of transmission is negligible) we have the longitude from Washington to Des Moines. Thus the time of sending the first signal in the first set, Friday March 13, as furnished by Washington observers was:

Washington Sidereal Time, 1st Signal	6h 58m 56.918s
Des Moines Sidereal Time, 1st Signal	5 52 36.167
Difference of Longitude	1h 6m 20.751s

In this manner the first and last signals in each set observed, for as many nights as we were able to observe the stars at both Washington and Des Moines (this means that it must have been clear at both places at the same time), give us independent data for the determination of our longitude. Four such values have been determined for Friday March 13, as scheduled below.

COINCIDENCES.

Friday March 13, 1914.

Coincidences	Radio No.	Interval on Home Clock First Set.	1st Sig. after Interruption	Radio No.
5h 53m 36s.0	100		5h 53m 57s.15	121
			54 56.70	181
5 55 59 .0	244	143 sec.	55 56.22	241
			56 55.81	301
5 58 32 .0	388	143 sec.	57 54.55	361
			58 54.85	420

Mean value of radio second on Home Clock is $143/144 = .993055$ s. Using the first, second and third coincidences respectively, the times of the first signal are

$$5^h\ 53^m\ 36^s.00 - (.993055 \times 99) = 5^h\ 51^m\ 57^s.688$$
$$\text{“}\ \ 55\ \ 59\ .00 - (.993055 \times 243) = \text{“}\ \ 51\ \ 57\ .687$$
$$\text{“}\ \ 58\ \ 22\ .00 - (.993055 \times 387) = \text{“}\ \ 51\ \ 57\ .687$$

Times of the last signal are

$$5^h\ 53^m\ 36^s.00 + (.993055 \times 320) = 5^h\ 58^m\ 53^s.778$$
$$\text{“}\ \ 55\ \ 59\ .00 + (.993055 \times 176) = 5\ \ 58\ \ 53\ .778$$
$$\text{“}\ \ 58\ \ 22\ .00 + (.993055 \times 32) = 5\ \ 58\ \ 53\ .778$$

Second Set.

Coincidences	Radio No.	Interval on Home Clock	1st Sig. after Interruption	Radio No.
			6h 1m 58s.75	61
			2 57.10	121
			3 57.85	181
			4 57.43	241
6h 5m 30s.00	274	5) 714 s		
		142.8	6h 5m 56s.95	301
			“ 6 56.60	361
			7 56.38	420

Mean value of radio second on Home Clock is 142.8/143.8 = .993055. Time of first signal is

$$6^h\ 5^m\ 30^s.00 - (.993055 \times 273) = 6^h\ 0^m\ 58^s.895.$$

Time of last signal is

$$6^h\ 5^m\ 30^s.00 + (.993055 \times 146) = 6^h\ 7^m\ 54^s.986.$$

CORRECTION TO SIDEREAL CHRONOMETER, TOBIAS 1370.

FRIDAY MARCH 13, 1914.

$d\theta = d\theta_i - aA_i - bB_i \mp cC_i$. (Where $i = 1, 2, 3, 4, \cdots n$)
$a = -2.69$ $b = -3.03$ $c = -2.05$

CLAMP EAST.

(1)	$d\theta$	$= 36^s.75$	$- .84$	$- 2^s.88$	$- 2^s.25$	$= 38^s.22.$	$+.22$
(2)	"	$= 36.70$	$- 2.91$	$- 1.12$	$- 2.33$	$= 38.40.$	$+.04$
(3)	"	$= 36.44$	$- 1.18$	$- 2.93$	$- 2.13$	$= 38.42.$	$+.02$
(4)	"	$= 36.56$	$- .97$	$- 3.16$	$- 2.21$	$= 38.48.$	$-.04$

CLAMP WEST.

(5)	$d\theta$	$= 32.43$	$- 1.60$	$- 2.57$	$- 2.05$	$= 38.65.$	$-.21$
(6)	"	$= 32.21$	$- .70$	$- 3.48$	$- 2.33$	$= 38.72.$	$-.28$
(7)	"	$= 40.52$	$- 7.32$	$- 3.77$	$- 6.01$	$= 38.06.$	$+.38$
				Mean $d\theta$		$= 38.435.$	

Taking the mean, exclusive of star Epsilon Draconis, which was observed wholly for azimuth correction, $d\theta = +38.48$ seconds.

Then in

First Set.

Time of first Radio Signal	$= 5^h$	51^m	$57^s.687$
$d\theta$	$=$		$38\ .48$
Local Sid. Time, 1st Signal	$= 5$	52	$36\ .167$
Wash. Sid. Time, 1st Signal	$= 6$	58	$56\ .918$
Difference of Longitude	$= 1$	6	$20\ .751$
Time of last Radio Signal	$= 5$	58	$53\ .778$
$d\theta$	$=$		$38\ .48$
Local Sid. Time, 420th Signal	$= 5$	59	$32\ .258$
Wash. Sid. Time, 420th Signal	$= 7$	5	$53\ .003$
Difference of Longitude,	$= 1$	6	$20\ .745$

Second Set.

Time of first Radio Signal	$= 6^h$	0^m	$58^s.895$
$d\theta$	$=$		$38\ .48$
Local Sid. Time, 1st Signal	$= 6$	1	$37\ .375$
Wash. Sid. Time, 1st Signal	$= 7$	7	$58\ .130$
Difference of Longitude,	$= 1$	6	$20\ .755$
Time of last Radio Signal	$= 6$	7	$54\ .986$
$d\theta$	$=$		$38\ .48$
Local Sid. Time, 420th Signal	$= 6$	8	$33\ .466$
Wash. Sid. Time, 420th Signal	$= 7$	14	$54\ .224$
Difference of Longitude	$= 1$	6	$20\ .758$

Taking the mean of these four values, as the adopted difference of longitude between Washington and Des Moines, determined on this date, we have, 1h 6m 20.752 s.

That we may compare the different nights' work and also to illustrate further the method of computation when only one coincidence in each set was observed, another schedule is submitted.

COINCIDENCES.

MONDAY MARCH 9, 1914.

First Set.

Coincidences	Radio No.	Interval on Home Clock	1st Sig. after Interruption	Radio No.
			$5^h\ 37^m\ 8^s.95$	61
			38 8 .45	121
$5^h\ 41^m\ 6^s.00$	300		40 7 .68	241
			42 6 .4	361
			43 6 .98	420

Second Set.

			$5^h\ 46^m\ 10^s.0$	61
			48 9 .25	181
			49 8 .50	241
$5^h\ 50^m\ 41^s.0$	334	$4)575^s$	50 8 .39	301
		143.75	51 7 .96	361
			52 6 .42	420

Mean value of radio second on Home Clock from first and second sets, is

$$\frac{143.75}{144.75} = .993091.$$

In first Set, Time of first Signal $= 5^h\ 41^m\ 6^s.0 - (.993091 \times 299) = 5^h\ 36^m\ 9^s.062.$

Time of last signal $= 5^h\ 41^m\ 6^s.0 + (.993091 \times 120) = 5^h\ 43^m\ 5^s.172.$

In Second Set, Time of first Signal $= 5^h\ 50^m\ 41^s.0 - (.993091 \times 333) = 5^h\ 45^m\ 10^s.297.$

Time of last Signal $= 5^h\ 50^m\ 41^s.0 + (.993091 \times 86) = 5^h\ 52^m\ 6^s.407.$

CORRECTION TO SIDEREAL CHRONOMETER, TOBIAS 1370.

MONDAY MARCH 9, 1914.

$d\theta = d\theta_i - aA_i - bB_i \mp Cc_i$. (Where $_i = 1, 2, 3, 4, \cdots n.$)

$a = -2.88$ Clamp E $\quad b = -.284$

$a = -3.11$ Clamp W $\quad c = -1.169$

CLAMP EAST.

(1)	$d\theta = 40.19^s - 1.27^s - .27^s - 1.76^s = 39.97^s.$		$+.54^s$
(2)	" $= 40.14 - .90 - .30 - 1.86 = 39.48.$		$+.05$
(3)	" $= 40.72 - .45 - .34 - 2.03 = 39.48.$		$+.05$
(4)	" $= 38.19 - 3.10 - .11 - 1.93 = 39.47.$		$+.04$
(5)	" $= 39.72 - 1.10 - .28 - 1.81 = 39.29.$		$-.14$

CLAMP WEST.

(6)	$d\theta = 35.60 - 1.37 - .27 - 1.76 = 39.00.$	$-.43$
(7)	" $= 36.58 - .61 - .33 - 1.99 = 39.51.$	$+.08$
(8)	" $= 35.74 - 1.84 - .23 - 1.69 = 39.50.$	$+.07$
(9)	" $= 36.52 - .50 - .31 - 1.92 = 39.25.$	$-.18$
(10)	" $= 36.08 - 1.12 - .29 - 1.83 = 39.32.$	$-.11$
	Mean $d\theta = 39.43.$	

First Set.

Time of first Radio Signal	$= 5^h$	36^m	$9^s.062$	
$d\theta$	$=$		$+ 39 .43$	
Local Sid. Time, First Signal	$= 5$	36	48 .492	
Wash. Sid. Time, First Signal	$= 6$	43	9 .114	
Difference of Longitude	$= 1$	6	20 .622	West
Time of last Radio Signal	$= 5$	43	5 .172	
$d\theta$	$=$		$+39 .43$	
Local Sid. Time, Last Signal	$= 5$	43	44 .602	
Wash. Sid. Time, Last Signal	$= 6$	50	5 .124	
Difference of Longitude	$= 1$	6	20 .522	

Second Set.

Time of first Radio Signal	$= 5^h$	45^m	$10^s.297$	
$d\theta$	$=$		$+ 39 .43$	
Local Sid. Time, First Signal	$= 5$	45	49 .727	
Wash. Sid. Time, First Signal	$= 6$	52	10 .324	
Difference of Longitude	$= 1$	6	20 .597	
Time of last Radio Signal	$= 5$	52	6 .407	
$d\theta$	$=$		$+39 .43$	
Local Sid. Time, Last Signal	$= 5$	52	45 .837	
Wash. Sid. Time, Last Signal	$= 6$	59	6 .385	
Difference of Longitude	$= 1$	6	20 .548	

Third Set.

(Not observed.)

Mean difference of Longitude $= 1^h \ 6^m \ 20^s.572$

Our part in the campaign extended from February 16, to March 30, 1914. Out of this mass of data eight nights' work proved to be available for the determination of the longitude. These results are tabulated herewith.

SUMMARY OF LONGITUDES BETWEEN WASHINGTON AND DES MOINES FOR DATES ON WHICH BOTH STAR TRANSITS AND RADIO OBSERVATIONS WERE OBTAINED.

Date 1914			1st. Set. Signal 1st.	1st. Set. Signal 420th.	2nd. Set. Signal 1st.	2nd. Set. Signal 420th.	3rd. Set. Signal 1st.	3rd. Set. Signal 420th.	Mean	v
	h	m	s	s	s	s	s	s	s	s
Feb. 20							20.467	20.457	20.462	+.178
Feb. 24					20.581	20.518	20.495	20.510	.526	+.114
Mar. 9	1	6	20.650	20.550	20.625	20.576			.600	+.041
Mar. 11	1	6	20.460	20.533	20.554	20.653			.550	+.091
Mar. 13	1	6	20.750	20.744	20.754	20.757			.751	−.110
Mar. 17	1	6	20.812	20.815	20.754	20.783			.791	−.150
Mar. 19	1	6	20.665	20.638	20.766	20.794			.716	−.075
Mar. 23	1	6	20.---		20.699	20.760			.730	−.089
							Mean of means		20.641	

Mean difference of longitude	1^h	6^m	$20^s.641$
Reduction to Washington meridian			$- .037$
Adopted Longitude	1	6	20 .604
Probable error of single observation			$\pm .097$
Probable error of final result			$\pm .034$

The only other attempt at an accurate determination of longitude in the State, so far as I have been able to ascertain, was made by Professor Simon Newcomb and Dr. Harkness, just before the total eclipse of the sun in August 1869. I quote their results from the report of the "Washington Astronomical Observations 1867".

TELEGRAPHIC DETERMINATION OF LONGITUDE BETWEEN WASHINGTON AND DES MOINES.

"Through the following record of the exchange of signals, the error of the Kissels clock is given on Washington Sidereal Time and the error of the chronometer Negus 1319 on the Mean Time at our temporary observatory at Des Moines.

On account of the great distance between the two cities it was impossible to transmit telegraphic signals from Washington to Des Moines. Therefore the line was broken up into a number of circuits of moderate length and signals transmitted from one to the other by means of automatic repeaters, as follows: Washington to Philadelphia, 138 miles; Philadelphia to Pittsburg, 335 miles; Pittsburg to Crestline, 189 miles; Crestline to Chicago, 279 miles, or Pittsburg to Chicago, 468 miles; Chicago to Keokuk, 251 miles; Keokuk to Des Moines 161 miles or Chicago to Davenport, 183 miles; Davenport to Des Moines 174 miles.

Collecting results obtained from the different nights' work we have:

Date 1896	Difference of Longitude	Wave and Armature time
July 26	1h 6m 16.08 sec.	.20 sec.
29	16.09 "	.16 "
30	15.82 "	.20 "
31	16.23 "	.17 "
Aug. 7	16.25 "	.21 "

Taking the mean we find that our temporary observatory at Des Moines was 1 hour 6 min. 16.09±0.05 sec. west of the east transit instrument of the United States Naval Observatory. But the east transit instrument is 42.9 feet, which is, in this latitude, equal to 0.036 seconds of time, to the east of the center of the dome. Hence we have as the result of these signals that the temporary observatory at Des Moines was

1 hour 6 min. 16.05s±.05 west of the center of the dome of the United States Naval Observatory.

On the evening of August 7, while I was exchanging Longitude signals with the observatory in Washington, Professor New-

comb and Dr. Peters came to the telegraph office, and compared their chronometers with the Washington clock. From these comparisons, Professor Newcomb found for the Court House Dome, 1 hour 6 min. 16.67 sec. and Dr. Peters found for the temporary observatory, 1 hour 6 min. 14.02 sec.

Applying to these results, the geodetic difference of longitude found by triangulation, we get for the Court House Dome,

$1^h\ 6^m\ 16^s.74$ (Harkness) $1^h\ 6^m\ 16^s.67$ (Newcomb) $1^h\ 6^m\ 16^s.80$ (Peters).

There was already on record a determination of the difference of longitude between Washington and Des Moines, made by the United States Coast Survey, as follows:

$1^h\ 6^m\ 17^s.26.$

Dr. Harkness noted this, and remarked "I am rather surprised at the large discrepancy between the Coast Survey, and myself."

Since the Drake Observatory is west of the Court House, we must either reduce my value to the Court House or Dr. Harkness's value to the Drake Observatory. Taking the distance of the Drake Observatory, West of the court House, as 1.55 miles, which distance was furnished by the City, we find that in this latitude (41° 34′ 54.7″) this is equivalent to 7.14 seconds of time. Subtracting this from my results we have as the longitude of the Court House at Des Moines,

1h 6m 13.46s ± 0.034s West of the New United States Naval Observatory.

The difference between this and Dr. Harkness's value ($3^s.28$) is in close agreement with the difference of longitude, ($3^s.63$) between the Old United States Naval Observatory, to which position Dr. Harkness's value undoubtedly referred, and the New Observatory at Georgetown Heights from which my determination was made.

The United States Coast and Geodetic Survey Report for 1884 (p. 424) gives for the longitude of the Court House at Des Moines referred to the Old United States Naval Observatory

$1^h\ 6^m\ 17^s.00.$

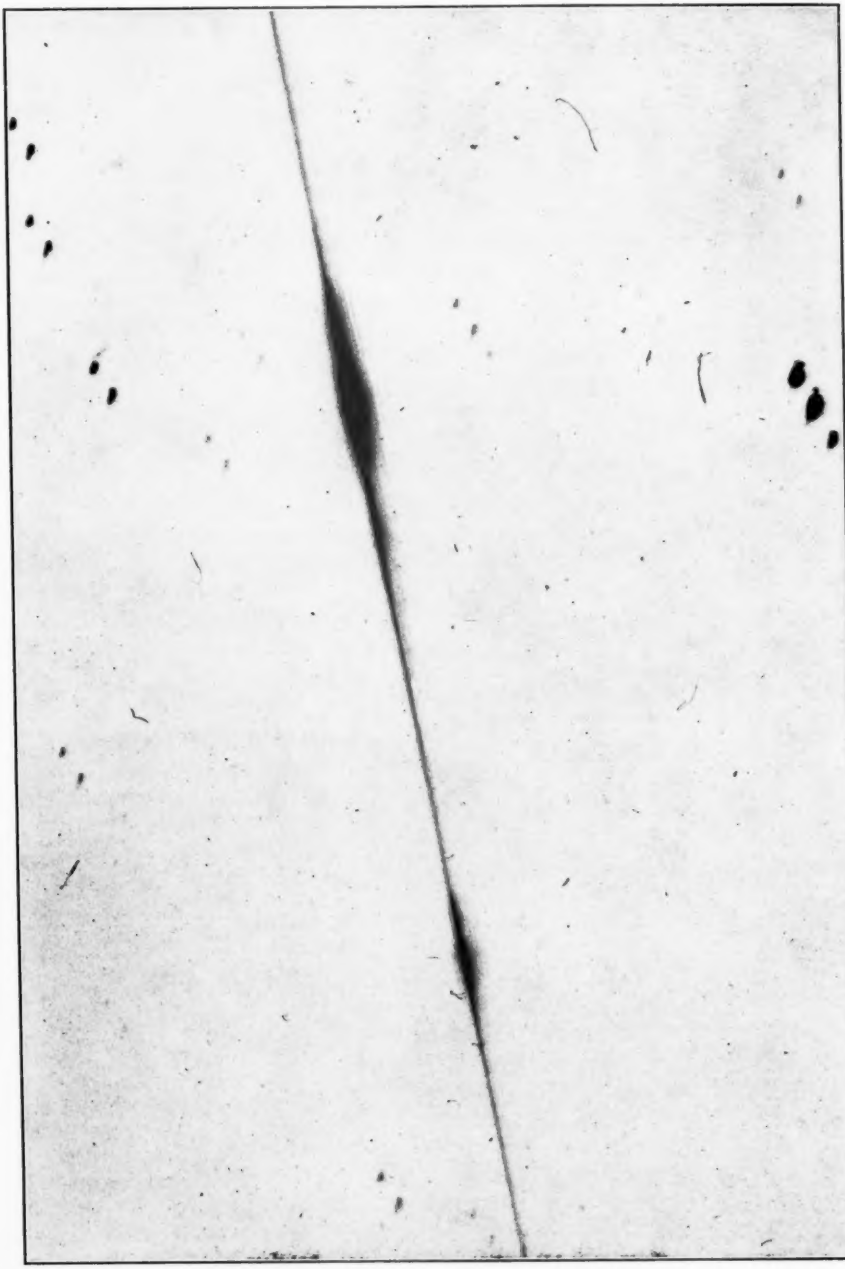
Applying the same correction to this, that have been applied to Harkness's value, gives for the Drake Observatory referred to the New Naval Observatory

$1^h\ 6^m\ 20^s.51,$

which is in very good agreement with my determination.

The writer wishes to acknowledge his debt of gratitude to his faithful assistants Messrs. S. J. A. Wifvat, and J. M. Davis, who assisted in taking the observations and to the Misses Cozine and Farris who did most of the computation.

PLATE VII



PHOTOGRAPH OF A METEOR TRAIL

By Joel H. Metcalf, Winchester, Mass., February 7, 1914. This plate shows only a part of the trail and is much enlarged. In order to bring out the faint companion trails, the engraver has had to make the main trail much harsher than it appears in the original photograph.

A PHOTOGRAPH OF A METEOR TRAIL.*

JOEL H. METCALF.

On February 27, 1914, on a plate, the middle time of which was 14^h 35^m Gr. M. T., an interesting meteor was photographed at this Observatory with the 12 inch and the 6 inch objectives while taking an asteroid plate. The exact time of the meteor cannot be given, as it was not seen by the assistant taking the plate.

The ends of the trail are in R.A. 12^h 19^m $16^s.7$ Decl. $+$ 16° 58′ and R.A. 12^h 37^m 53^s Decl. $+$ 18° 52′. The length of the trail is approximately 4°.75. Throughout its length the trail is broader than the star trails of similar density.

Assuming the meteor began in R.A. 12^h 19^m Decl. $+16°$ 58′, it started very faint and gradually increased in brightness through 4° of its photographed path and suddenly burst out with a great accession of light and was followed by three other outbursts, each fainter than the preceding one.

After the fourth outburst the meteor made no impression on either plate.

At the point of largest outburst the trail is 1′.0 broad and shows that the meteor was composite, consisting of at least four objects.

At the next outburst three of these objects are visible, at the third two and at the last the meteor is so faint that only the main meteor is seen.

An examination of the plate at the point of these outbursts shows that the broadening is not due to any burnt out effect on the plate, for nowhere does such photographic irradiation exist. It is therefore evident that the meteor was in several parts and that these parts grew brighter together and faded together. This could only be if the outbursts were due to a train of meteors passing through several denser strata of the earth's atmosphere and so received the greater illumination at the same point in their paths or else the increased illumination came only to the central and brighter part illuminating the outer components by reflected light in part. This would leave unexplained how the central and presumably larger meteor should brighten up so much more than the outlying ones when we should expect the greater friction on the outer ones.

* From the *Astronomische Nachrichten*, No. 4770.

If we assume a stratification of the atmosphere, it is not necessary to assume that the parts were closely together for they may have been in practically the same path but separated.

If however the smaller ones were photographed by partly reflected light from the main meteor, they must have been closely bunched.

Another supposition is that we have here a mass partly solid and partly gaseous moving as a ball through the air with a diameter of at least 1′ and subject to sudden increases of brightness to be compared with explosions.

Winchester, Mass., 1914 June 26.

CLAUDIUS PTOLEMAEUS.

CHARLES NEVERS HOLMES.

The names of Eudoxus, Callippus, Aristotle, Aristarchus and Hipparchus are well known to all astronomers, and the name of Claudius Ptolemaeus is just as well known. Of these names, Hipparchus and Ptolemaeus are more closely associated than are the others, for, although the former lived in the B.C. era and the latter in the A.D. era, Ptolemaeus, or Ptolemy as he is more commonly called, relied greatly upon the astronomical work left by Hipparchus, whom he much admired. After the death of Hipparchus—who died in the second century, B.C.—there was no history of astronomy, so to speak, for almost three hundred years. Then Ptolemy, his great successor, appeared, and the so-called Ptolemaic System remained a firm astronomical belief for many centuries.

Very little is known about Claudius Ptolemaeus. He was a native of Egypt; but that does not mean necessarily that he was a descendent of the Royal Ptolemies. He made his first recorded firmamental observation in the year 127 A.D. and the last one in the year 151. He seems to have been a resident of or near Alexandria; but more than that there is very little known about his personal history. Nevertheless, he was one of the greatest of astronomical philosophers of ancient times, and his influence and theories lasted intact for some fourteen centuries. Even today certain of his deductions are as true as they were then, and his erroneous theories are still believed by some people to be correct. And not only was he one of the greatest astronomers of all time but he was also a famous geographer. During his astronomical labors Ptolemy

collected and published the work of his predecessors, as well as expressing and publishing his own opinions. So sincerely and strongly did he state his own theories that even though some of them were not true they had every appearance of the truth.

The astronomical work by which he is so well remembered consists of a volume of thirteen books. These thirteen books were called by the Arabs the "Almagest" or the "Greatest." They were certainly well named. The "Almagest" contains, as we should expect, much of the records and work of astronomers preceding Ptolemy—especially Hipparchus; but it also contains the theories, right and wrong, of Ptolemy himself. Of the 13 books making up this remarkable volume, the first and the second book have to do with the motion of the so-called "celestial sphere" and the general movement of the sun, moon and planets. The third book treats of the length of a year and a theory respecting the sun. The fourth book considers the length of a month and a theory regarding the moon. The fifth book describes the construction and use of the "Astrolabe"—a combination of graduated circles—which was the chief instrument employed by Ptolemy. The sixth book is taken up with explanation and discussion respecting eclipses. The seventh and the eighth book contain a catalogue of stars (more than a thousand) and a consideration of precession. The other books—five in number—deal with a theory respecting the planets. Besides the "Almagest," Ptolemy is said to have written other astronomical treatises; and he is known to have composed an important book on geography.

But by most of us Ptolemy is remembered because of the so-called "Ptolemaic System." Briefly described, this system declared that our earth is the center of the Universe, while around our motionless planet revolve in respective order the Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn (for at that time only five planets besides our own world were known). Then still further distant there revolved around our earth all the other stars of the Universe which were set in a sort of hollow, crystalline, transparent sphere. In other words, the apparent movement of heavenly bodies was wholly explained by their motion about the earth; the "celestial sphere" in which the stars were set revolving once every twenty-four hours wholly around our central planet. This so-called "Ptolemaic System" is very old—it may be that the untutored star-gazers of pre-historic times had a dim conception regarding it. Aristotle had a very definite idea of such a theory, although, on the other hand, Pythagoras taught the doctrine that the sun is the central body, and that all the planets revolve around him. But although the belief that our earth was the real center of the Universe with everything else in the Universe revolving around it was so old, it remained for Ptolemy to persuade his fellow men that there could

be no mistake about the matter, and he left such a lasting impression upon them that some fourteen centuries passed before they wholly changed their minds. But during all this time our earth had been revolving around the sun and not the sun revolving around the earth.

We are perhaps rather inclined to remember Ptolemy for his great mistake rather than for his great assertion that our world is round. Indeed, this assertion of his indicates how correct his astronomical ideas naturally were; but in the case of the Universe his knowledge was not sufficient to perceive the truth. Respecting his own world, Ptolemy had all the information necessary to discern the terrestrial rotundity. He arrived at his conclusions in this matter very much as we should today, for example, that out at sea a ship at a distance slowly sinks from sight. However, he had to work his proofs out for himself, and he satisfied himself that the earth was round by several of these proofs. One of these proofs was that the farther south a traveler goes, the lower some of the stars well-known "up north" sink towards the horizon while new constellations rise in the southern firmament. This showed that the surface of the earth could not be flat. Ptolemy also argued that if the surface of the world were flat, sunset would necessarily occur at exactly the same time everywhere, whereas the time of sunset varies a great deal. By comparing the different times when an eclipse of the moon had been recorded, he proved that the more easterly a place happened to be from Alexandria the later would be the time of day in that place. In other words, the citizens of a town situated eastward of Alexandria would see the sun set and evening begin before the citizens of Alexandria would see sunset. Thus, the world must be round, because otherwise the time of sunset would be the same at both the town east of Alexandria and at Alexandria.

To us of the twentieth century this sort of reasoning may seem a little simple and primitive; but up to the days of Ptolemy the general belief was that the world was "flat", being surrounded by some kind of boundless ocean. Not only did he prove that the earth was round but he also affirmed that it was absolutely unsupported in any material way. That is, that the world is a huge round sphere suspended in space. surrounded on all sides by the bright stars of the Universe. This was certainly a great step forward in the direction of modern astronomical science; and had Ptolemy used as correct judgment with respect to his other theories as he did regarding his terrestrial theories, his name would be far more illustrious today. Unfortunately for himself and for science, his next step proved to be a mistake, although it was a popular and prevalent astronomical error of that age. Ptolemy had proved that our world is round and is hanging in space; but now he was obliged to explain the sun, moon, planets and the other stars of the firmament.

None of these bright bodies remains at rest in the sky. During the day King Sol is in motion; during the night the moon and the planets, as well as the "fixed stars" have an apparent motion. What causes all these bodies to move? And what relation do they bear to the world? In regard to their seeming motion, that can be explained in only two ways: either they move or the earth moves. Pythagoras declared that the world moves; but Ptolemy did not see how his own planet could be in rapid motion without creating such an agitation in the atmosphere (which he believed would remain as though unattached to the terrestrial surface) that the whole human race would be killed. That the air about him was usually still was proof to his mind that the earth had no motion whatsoever. It is true that for the "celestial sphere" to revolve once around the world in twenty-four hours would mean a well-nigh impossible velocity. To explain the movement of the fixed stars by the simple rotation of his own planet was more natural; but Ptolemy could not believe that his world was rotating upon its axis. One thing was certain—the stars of the firmament were in constant motion, and, since it seemed to him impossible that his own planet was moving, it must be that the movements of these constellations and suns were real. As we view his decision in the light of present day knowledge, it appears more like the judgment of a child than of a grown man; but were we to grope amid the same astronomical darkness as did Ptolemy, most of us would reach in all probability the very same conclusion.

Ptolemy had now decided that the world was round and that it hung absolutely motionless in space. Of course, the thought came to him that although his planet did not rotate, nevertheless it might have some sort of slight movement; but his decision in this matter was that the earth could have no motion at all, as otherwise the constellations would change in appearance. But certainly something caused the fixed stars to move across the firmament, and at last he came to the famous conclusion that these stars were merely bright points firmly attached to the inside of a very vast globe. Since this globe or celestial sphere was in motion, it carried the stars around and around the earth, which was exactly at the center of this globe. Ptolemy also reached the conclusion that the celestial sphere must be very stupendous, for no matter at what points he stood the apparent brightness of the suns was unchanged.

In other words, Ptolemy accounted for the fixed stars just as though they were all afar off, and each of them was exactly at the same distance from our earth. He argued that were it otherwise, and these stars were not set firmly in a celestial sphere, the constellations would not keep their constant relative positions. The constellations never changed in appearance, and they certainly would change were the earth to move

at all. Moreover, the world must be in the very center of the vast celestial globe, for were it not, the fixed stars would not—each one of them—seem to move with such perfect regularity. It was perhaps because he was so great a mathematician that Ptolemy preferred such a complex theory to a simple one. It may have been that he was not as remarkable in astronomical observations as in astronomical mathematics. However it was, he made his famous decision to explain the apparent motion of the fixed stars, and having made that decision he had to explain consistently the movements of sun moon and planets.

First, there were the monthly movements of the moon and the yearly movements of the Sun. Both these movements were very different from those of the fixed stars; but he got around this difficulty by saying that the Sun and Moon were independent of the stars and possessed motions of their own. That is, they moved in perfect circles around the earth, which was in the exact center of both their circles. Thus, it could be understood that the moon had a period of a month and the sun a year. But the planets possessed different movements from those of the Sun and Moon. Again, Ptolemy was successful in inventing a theory to fit his erroneous conclusions. He declared that Mercury and Venus were between the Sun and the earth, and that each revolved in a small circle, this circle being carried around the world as the Sun moved around it. That is, these circles in which Mercury and Venus respectively revolved followed the yearly movement of the Sun, just as though attached to him by some rigid arm; so that while Venus was revolving around its circle, it was always associated with the Sun, appearing first on one side of him then on the other. With regard to Mars, Jupiter and Saturn—the other planets known to Ptolemy—these were situated beyond the sun, and like Venus and Mercury they all revolved in circles which followed the yearly progress of King Sol. It is thus evident that Ptolemy divided his Universe materially into three parts: (1) our earth; (2) the Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn, at increasing distances from one another; and (3) the fixed stars and constellations set in the celestial sphere. As has been said, all these suns and planets were in constant motion around an utterly motionless earth.

Such, briefly, is a very incomplete account of Claudius Ptolemaeus's ideas respecting the Universe as known by him. Regarding Ptolemy himself, astronomers have several opinions; and his work has been criticised as being largely based on the previous work of Hipparchus and because his observations seem often to be poorly made. Nevertheless, Ptolemy was a most accomplished and original mathematician; and he certainly was one of the great astronomers, his influence and

theory lasting almost absolute for many centuries. But error—particularly an error as great as that respecting the motion of the suns and planets—would necessarily be corrected in time, and the Copernican System, advocated by Nicholas Copernicus in 1543, taught our world that the Sun is the real center of its solar system, and that all the members of this system, including the earth, revolve around the Sun. Such is our belief today; and each increase in astronomical knowledge, each new sidereal discovery, merely reaffirms the truth of the Copernican System and the error of the Ptolemaic System.

Boston, Mass.

A PRACTICAL EXPLANATION OF THE GYROSCOPE.

C. F. BUGBEE.

The gyroscope is one of the most interesting and fascinating of scientific puzzles. Every scientist has studied it; most of them have admitted that it is still as much of a mystery as ever.

A few of the highest mathematicians claim they have solved it, but their explanation is so intricate and complex that no one but themselves can understand it.

There have been many theories advanced, but none of them will satisfactorily explain the phenomena. The theory now generally believed is accepted only for want of a better one. It has been said of it that "It must be so, as there could be no other."

One man spent many years working out this theory and found, after all his efforts, that the gyroscope gyrated in the opposite direction from that which his calculations had indicated. Then, to make this solution consistent, the theory was advanced; that the phenomena of gravitation is not due to an attraction in the earth, but to a pressure from space.

This is the conclusion of many distinguished scientists, yet there has been no experimental demonstration, except the gyroscope. The principal reason for this theory is that the gyroscope would otherwise gyrate in the opposite direction from that which their solution indicates.

Scientists and mathematicians have ever been looking for some obscure and unknown law to explain the gyroscope. That the phenomena might be explained by any of the elementary laws discovered by Newton never seemed possible, as the gyroscope apparently violates all known laws of motion.

Though Newton's laws of motion have stood just as he made them and hold true in all cases, the gyroscope seemed to be the one exception.

But by modifying one law with another, the phenomena can be solved by applying Newton's laws.

The gyroscope violates Newton's laws when it resists any force applied to it that tends to change its plane of rotation, it will only change its plane at an angle to the direction of the force applied, and this angle will widen as the speed increases.

According to Newton's second law, every motion or change of motion is proportional to the acting force, and takes place in the direction of the straight line along which the force acts.

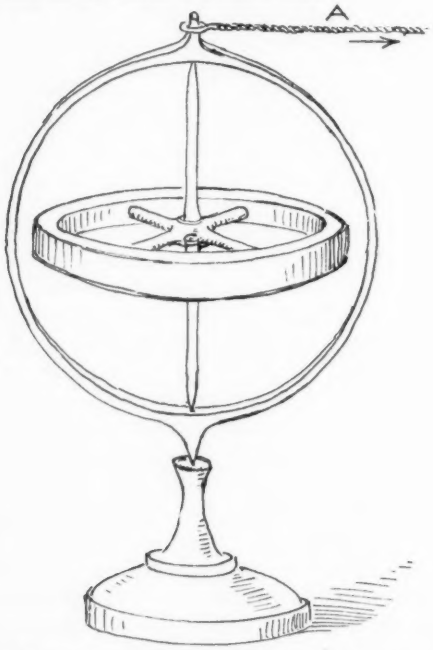


FIG. 1. THE GYROSCOPE REVOLVING ON A PEDESTAL.
A—Force put on wheel to change its plane of motion.

The gyroscope is apparently a violation of this last law, but there is another law which modifies it: All bodies continue in a state of rest, or motion in a straight line, unless acted upon by some external force that compels a change; but no matter how great the force may be, *a body cannot be instantly put in motion.*

This is the resistance due to inertia, and causes the phenomena of the gyroscope by delaying the action of the force on the wheel.

Suppose a toy gyroscope is put on a pedestal, and a string is tied to the upper end of the axle, (Fig. 1). A force put on the string will tend to change the horizontal plane of the wheel; now, by Newton's laws:—

1. Every part of the wheel has weight, and therefore inertia to resist a change of motion.

2. The inertia will be the same whether the wheel is revolving or not, but if it is not revolving the inertia will make no appreciable difference, and the wheel will move towards the string, according to Newton's second law.

3. The wheel cannot move towards the string until its inertia is overcome, and no matter how great the force is *it cannot overcome this inertia instantly.* Then, if it is revolving rapidly, *the wheel will turn on its axis before it can move in response to the pull.*

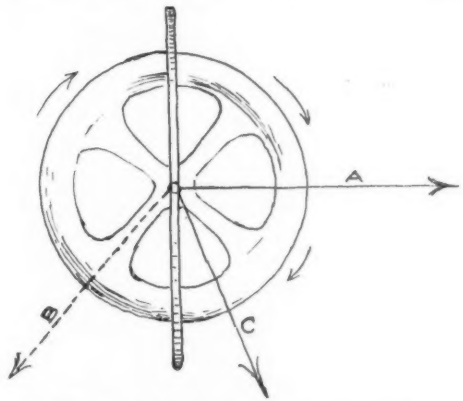


FIG. 2. THE RESOLUTION OF FORCES. TOP VIEW.

A—Direction of force from string. B—The direction a force from A would act on the wheel, if it had moved that far before its inertia were overcome. C—Direction of combined forces, towards which the gyroscope would move.

This has the effect of changing the direction the pull will act on the wheel. The wheel will move towards the string at an angle depending on how far the wheel has turned while its inertia is being overcome.

The entire phenomena depends upon the fact that the force cannot act quickly enough to overcome the inertia before the wheel has turned part way around.

The result of the force from the string acting on the frame, and the same force acting on the wheel in another direction, will move the gyroscope in a direction between the two forces, depending on the direction and magnitude of each. (Fig. 2).

Every characteristic of the gyroscope confirms this theory. There will be no gyroscopic action whatever unless there is some force put on it to change its plane of motion.

A gyroscope will not support itself if is is not allowed perfect freedom of movement. If the free end is held in the hand, no sustaining force will be felt, because the hand relieves the wheel of the force of gravity. If the arm sustaining the gyroscope project over the point of support on the pedestal, and a weight is placed on the arm that will just balance the weight of the gyroscope (Fig. 3), the gyrations will stop, because there will be no force on the wheel. If the weight overbalances the gyroscope, it will revolve around the pedestal in an opposite direction than it would without the weight, or if the weight underbalanced the gyroscope. The difference depends on whether the wheel is pulled down by gravity, or forced up by the weight.

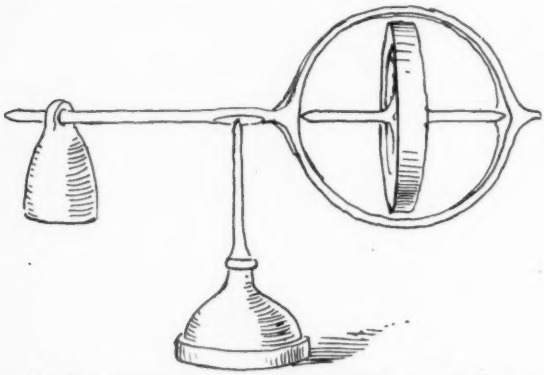


FIG. 3. THE GYROSCOPE BALANCED BY A WEIGHT, ON PEDESTAL.

The direction of gyroscopic action depends on the direction in which the wheel revolves in relation to the direction of the force put on it.

When the gyroscope is used for steadying mono-rails, aeroplanes, etc., two parallel wheels revolving in opposite directions, are necessary. Any force put on them will act on each wheel at an opposite angle, and they will counteract a force put on them to change their plane, equally in any direction.

The gyroscope is also used as a compass.

If the gyroscope has all degrees of free rotation, and is equally balanced, it will move slowly and gradually to a position parallel to the earth's axis, always pointing north and south.

Every body in the Universe exerts a certain attractive force on every other body. This is known as gravitation.

When a gyroscope is in perfect equilibrium with the gravitation of the earth, that is; nothing to cause a change of plane, there will always be a slight attraction from the sun and moon. The revolution of the earth would change the plane of the gyroscope in relation to this attraction. The gyroscope resists this change of plane, and moves at an angle to the direction of the attraction, until it assumes a position with its axis parallel to the Earth's. In this position, when the gyroscope and the point on the earth are revolving in the same plane, the revolution of the earth would not have the effect of changing the plane of the gyroscope.

330 Lick Bldg.
San Francisco, Cal.

THE ASTRONOMER.

Seated in silence within the dome,
I gazed on the Milky Way,
Composed of suns all like our own,
Each traveling on its way
Through infinite stretches of starry space
Where mystery holds her sway.

What secrets lie hid in the depths of space
Where gravity reigns supreme,
Midst stars of orange and purple
And clusters and starry streams.
Compared with the vastness of infinite space
How tiny our solar system seems!

How Galileo must have felt
On that memorable day
When first he turned his "optik tube"
On the wondrous Milky Way;
Resolved it into separate stars
Each vast and far away!

W. EDGAR WOOLARD.

2106 Downing St.
Denver, Colorado.

SUNSPOTS CAUSED BY PLANETS.

J. S. RICARD.

It does not take a thousand years to make an induction about things of frequent occurrence, for instance, sunspots and correlated phenomena. A sunspot period of 11.11 years may be deemed sufficient. One year and even six months of continuous observation may also lead to results that further observation will not destroy, but reaffirm.

In the present paper, we intend to place before the public the mathematical process which already for one year has yielded the most satisfactory results regarding the origin of sunspots and faculae. In a previous essay published in POPULAR ASTRONOMY, we sketched a method of forecasting long in advance the arrival of areas of low barometer on the Pacific Coast, so far as it is covered by the weather maps of the United States and the Canadian Dominion. This method depends vitally for its inerrancy on sunspots and faculae old and new; and, therefore, to a variable extent, on our ability to foretell *where* on the surface of the sun these disturbances are first formed, so as to know *when*, by solar rotation, they shall reach any one of the *four* critical positions heretofore described.*

Waiving for the time being the claim that sunspots and faculae are of planetary parentage—a thing which our latest researches seem to have placed beyond doubt,—we would simply state in this connection that when planets, viewed from the sun's center, have the same longitude, or stand nearly diametrically opposite in line with the sun, sunspots or faculae, generally the latter, begin to form at those points on the sun's surface which have the same longitude as the conjoined planets themselves or have the same longitudes that the opposite planets have. Hence the fear of a new sunspot appearing on the scene and giving the lie to a monthly weather forecast which had not reckoned with it, is now we hope forever dispelled; and the only practical trouble that remains is the task of converting celestial longitudes and latitudes into heliographical ones. There is more than one way of doing so, but we have preferred following in the footsteps of Carrington by adopting the classical method of the Greenwich Observatory.

I. Let *ABC*, Fig. 1, be a spherical triangle on the sun's surface, *A* one of the poles of the ecliptic transferred to a corresponding point on

* Cf. P. A. Vol. XIX. p. 224 et. seq.

the sun, P_o a point on the sun just opposite the sun's apparent center on the imaginary line joining the centers of the earth and the sun, B a point on the sun's surface which has the same ecliptical coördinates as a planet at heliocentric conjunction or opposition, then, calling ϕ_o and λ_o the celestial latitude and longitude of B, $\odot$ the longitude of the sun and ρ the angular distance from B to P_o,

$$b = \frac{\pi}{2}$$

$$c = \frac{\pi}{2} - \phi_o$$

$$A = \pi + \odot - \lambda_o,$$

which is the difference between the celestial longitudes of the earth and the planet under consideration. If the planet was ahead of the earth, we should write

$$A = \lambda_o - (\pi + \odot).$$

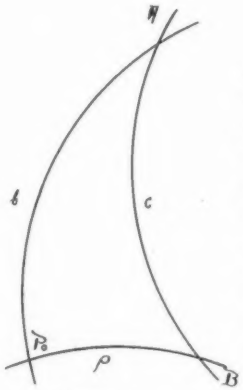


FIGURE 1.

Let P_o denote, in addition, the position-angle of B from the north or the south end, as the case may be, of the axis of the ecliptic. The quantities ϕ_o and λ_o are calculated from data in the astronomical Ephemerides. The usual process of interpolation with its careful balancing of differences of various orders, can be gone through; or, which is much easier, an equation of the first degree can be used with advantage for the present purpose. The position-angle P_o and the side ρ can then be found by Napier's Analogies, thus:

$$\tan\frac{B+P_o}{2} = \cot\frac{A}{2}\,\frac{\cos\dfrac{b-c}{2}}{\cos\dfrac{b+c}{2}}$$

$$\tan\frac{B-P_o}{2} = \cot\frac{A}{2}\,\frac{\sin\dfrac{b-c}{2}}{\sin\dfrac{b+c}{2}}$$

$$\tan\frac{\rho}{2} = \tan\frac{b-c}{2}\,\frac{\sin\dfrac{B+P_o}{2}}{\sin\dfrac{B-P_o}{2}}$$

II. See Fig. 2. On the line which joins the centers of the earth and the sun, lay a plane and make it pass through one of the poles of the heavens; then, pass another plane through the same line and the corresponding pole of the ecliptic; let α be the dihedral angle comprehended between them, ϵ the obliquity of the ecliptic, P the chosen pole of the heavens p the corresponding pole of the ecliptic. Draw an arc of the celestial equator and an intercepting arc of the ecliptic with corresponding circles of latitude and let C be the apparent center of the sun. $\odot$ shall, as usual, denote the longitude of the sun.

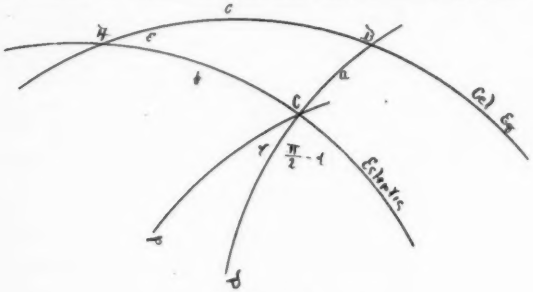


FIGURE 2.

Consider the spherical triangle ABC. It is right-angled at B. Hence,

$$\cos b = \cot A \cot C,$$

where

$b = \odot$, the longitude of the sun,
$A = \epsilon$, the obliquity of the ecliptic,
$C = \frac{\pi}{2} - \alpha$.

Substituting,

$$\cos \odot = \cot \epsilon \tan \alpha$$

$$\therefore \tan \alpha = \frac{\cos \odot}{\cot \epsilon}$$

or

$$\tan \alpha = \tan \epsilon \cos \odot$$

III. See Fig. 3. Once more, imagine a line joining the centers of the earth and the sun; lay a plane on this line and one of the poles of the ecliptic and another plane on the same line and the corresponding pole of the sun. Draw intersecting arcs of the sun's equator and of the ecliptic together with corresponding arcs of circles of latitude. Let I denote the inclination of the sun's equator to the plane of the ecliptic, C the apparent center of the sun, P the pole of the ecliptic, p the corresponding pole of the sun, β the dihedral angle included between the two

planes passed through the earth-sun line and the two poles just mentioned and ☊ the longitude of the ascending node.

Spherical triangle ABC is right angled at B. Hence, by inspection,

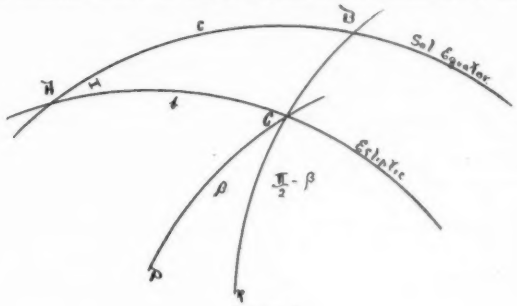


FIGURE 3.

$$\cos b = \cot A \cot C,$$

where evidently,

$$b = \odot - \Omega,$$
$$A = I,$$
$$C = \frac{\pi}{2} - \beta,$$

Substituting,

$$\cos (\odot - \Omega) = \cot I \cot \left(\frac{\pi}{2} - \beta\right)$$
$$= \cot I \tan \beta$$

or,

$$\therefore \tan \beta = \frac{\cos (\odot - \Omega)}{\cot I}$$
$$\tan \beta = \tan I \cos (\odot - \Omega)$$

Summing up Nos. II and III.

Thus we know the angle α at the center of the sun comprehended between two planes passing respectively through the poles of the heavens and of the ecliptic and the so-called "earth-sun" line; and also the angle β at the sun's center comprehended between two planes passing respectively through the poles of the ecliptic and of the sun and the same earth-sun line. The algebraic sum of these two angles is the well-known position-angle P of the north end of the sun's axis from the north point of the sun, so that we have

$$\alpha + \beta = P,$$

the values of the latter being tabulated in the "Companion to the Observatory", page 21, and also but recently in the American Ephemeris and Nautical Almanac, under the heading "Ephemeris for Physical Observations of the Sun," page 609.

IV. See Fig. 4. The earth, as seen from the sun, not only may be but is treated like any other planet. Hence its heliocentric coördinates are both a matter of interest and frequent application. An observer with his eye at the sun's center would find that its longitude was always 180° added to that of the sun and that its center stood sometimes slightly above and sometimes slightly below the plane of the ecliptic, in consequence of which a line drawn from the earth's center parallel to the plane of the ecliptic, just above or below his line of sight, would

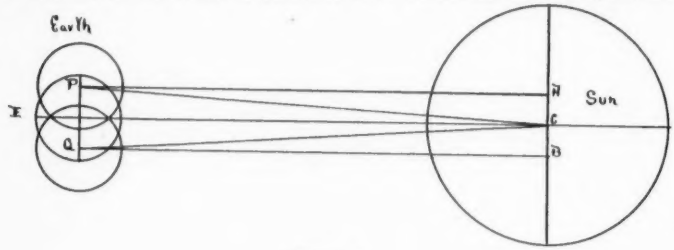


FIGURE 4.

strike the sun either above or below its real center at some point which is called its *apparent* center; and, moreover, this point would stand just as much above or below the real center as the observer in the sun's center saw the earth's center above or below the plane of the ecliptic. Figure 4 makes this matter clear. The line *EC* is supposed to lie wholly in the plane of the ecliptic, *C* is the sun's real center, *A* and *B* the apparent centers. The rest of the figure is self-explanatory.

But what it imports most to take note of, is that the *ecliptical* latitude of the earth's center equals the heliographical latitude of the sun's apparent center. The same does not, of course, hold for the longitude, as will be shown presently.

It will not be inopportune to define here what is meant by the Sun's Central meridian. Imagine three points in the same plane. Let one of these points be the sun's pole, the other the sun's real or apparent center, the third the earth's center. Let a solar latitude circle sufficiently produced, pass through these three points; it will be the sun's Central meridian. It follows that when we know the earth's heliocentric longitude, *ipso facto* we know also the heliocentric longitude of the sun's Central meridian, and the same can be converted into heliographic, as can be gathered from the following.

V. See Fig. 5. In this figure, *C* is the earth's center, *P* the pole of the ecliptic, *p* the sun's pole, *pBC* the sun's Central meridian which cuts the sun's equator in *B* and the plane of which, sufficiently produced, meets the earth in *C*, *A* the ascending node and *I* the inclination of the sun's equator to the plane of the ecliptic.

As a matter of course, the spherical triangle ABC has a right angle at B. Hence, at sight,

$$\cos I = \cot b \tan c.$$

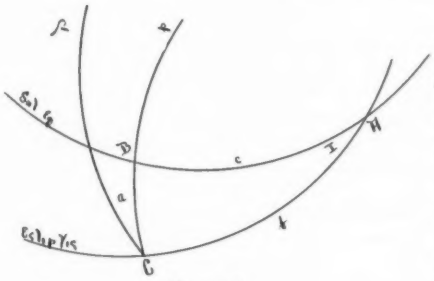


FIGURE 5.

By the figure, the side b is the heliocentric longitude of the earth, or, which amounts to the same, the heliocentric longitude of the sun's Central meridian, reckoned from the ascending node; and the side c, as an arc of the sun's equator, beginning at the ascending node and ending at B just opposite the apparent center at the end of the earth-sun line, is the heliographic longitude of the earth's center, which is the same as that of the sun's Central meridian and the same again, according to technical parlance, with that of the sun's apparent center. So we have

$$b = \pi + \odot - \Omega$$

and, $c = L$, the heliographic longitude of the sun's center.

Substituting,

$$\cos I = \cot (\pi + \odot - \Omega) \tan L$$

$$= \cot (\odot - \Omega) \tan L$$

$$\therefore \tan L = \frac{\cos I}{\cot (\odot - \Omega)}$$

or,

$$\tan L = \cos I \tan (\odot - \Omega)$$

Again, from the same triangle.

$$\sin a = \sin I \sin b,$$

The side a, as an angular distance from the sun's equator to the earth's center, measured on a solar latitude circle, is manifestly the heliographic latitude of the earth, which, as previously shown, is always equal to the heliocentric latitude of the sun's apparent center. Its usual name is D. Hence,

$$\sin D = \sin I \sin (\pi + \odot - \Omega),$$

$$= - \sin I \sin (\odot - \Omega).$$

But if we reflect that the same side a is always measured from the sun's equator downward and not upward towards the sun's north pole, we have to look on it as a negative quantity. Hence

$$a = -D$$

$$\sin(-D) = -\sin D$$

and

$$-\sin D = -\sin I \sin(\odot - \Omega)$$

and finally, by a mere change of signs

$$\sin D = \sin I \sin(\odot - \Omega)$$

which is the accepted and working formula.

It may be well to observe here that the varying values of L and D, like those of the position angle P of the north end of the sun's axis from the sun's north point, are tabulated for intervals of five days in the "Companion to the Observatory," page 21, and also in these latter days in the "American Ephemeris and Nautical Almanac," page 609. Unfortunately for our purpose and most other purposes, L is reduced from the ascending node to the Carrington meridian which is of no use to us. What we want is a reference to the sun's central meridian facing the earth at any given date, as our point of departure.

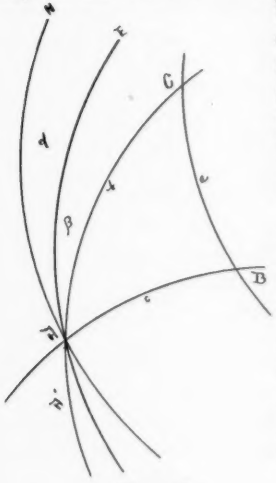


FIGURE 6.

VI. See Fig 6. We will now seek to find the heliographic coördinates of point B in Fig. 1, which is already heliocentrically known. Let C be the sun's pole, E the pole of the ecliptic, N the pole of the heavens, the latter two being transferred to the sun, A the apparent center of the sun and A' its real center; also, let ϕ denote the heliographic latitude of B and λ its heliographic longitude. In spherical triangle ABC,

$$\cos a = \cos b \cos c + \sin b \sin c \cos A,$$

this being the fundamental formula of spherical trigonometry.

$$a = \frac{\pi}{2} - \phi,$$

since it is the complement of the heliographic latitude of B;

$$b = \frac{\pi}{2} - D,$$

since it is the complement of the earth's heliocentric latitude or of the heliographic latitude of the sun's apparent center;

$$c = \rho.$$

Hence,

$$\begin{aligned} \cos a &= \sin \phi, \\ \cos b &= \sin D, \\ \cos c &= \cos \rho, \\ \sin b &= \cos D, \\ \sin c &= \cos \rho. \end{aligned}$$

Substituting,

$$\sin \phi = \sin D \cos \rho + \cos D \sin \rho \cos A$$

By the Law of Sines, applied to triangle ABC, we also have

$$\frac{\sin C}{\sin c} = \frac{\sin A}{\sin a}$$

$$\therefore \sin C = \sin c \ \frac{\sin A}{\sin a} .$$

But

$$C = L - \lambda ,$$

i.e., angle C is the difference between the heliographic longitude of the earth's center and the heliographic longitude of B, both of them being counted from the ascending node. Point B is supposed to be situated somewhere on the surface of the sun, and, as we have already determined its latitude, it remains that we do the same for its longitude.

Substituting for a, c and C, we obtain

$$\sin (L - \lambda) = \frac{\sin \rho \sin A}{\cos \phi} .$$

There is yet to be found a convenient substitute for A in the two last equations, in terms of quantities already determined. For this purpose, we have only to recollect that we called P_o the position angle of B, taken in regard to either end of the axis of the ecliptic, and that the angles α and β have already been explained so as to have

$$\alpha + \beta = P,$$

whence

$$\beta = P - \alpha.$$

Now, by referring once more to the general spherical triangle ABC, we have

$$\begin{aligned} BAE &= P_o, \\ CAE &= \beta. \end{aligned}$$

Hence angle A or

$$\begin{aligned} BAC &= BAE - CAE, \\ &= P_o - (P - \alpha), \end{aligned}$$

or, which is more convenient for the computer,

$$A = P_o - \beta.$$

Hence, by a final substitution,

$$\sin \phi = \sin D \cos \rho + \cos D \sin \rho \cos (P_o - \beta)$$

and

$$\sin (L - \lambda) = \frac{\sin \rho \sin (P_o - \beta)}{\cos \phi}.$$

Thus is the transformation of heliocentric-ecliptical spherical coördinates into heliographic ones completely effected. Special attention is called to the quantity $L - \lambda$, which refers solar phenomena to the sun's central meridian of any given date as the most convenient circle of reference, and singles out the famous point B, where the spot or facula, generally the latter to begin with, is first formed under planetary influence, wherever it may be situated on the sun's surface, whether in front, or in back, on the eastern or the western quadrants, in a high or low or middle latitude.

The same difference may turn out positive or negative: if the first, the spot will be at the west of Central; if the second, at the east of Central.

As a classical example, we may refer to the Venus-Jupiter heliocentric conjunction, (☌ ♀ ♃) of September $23^d.36$, 1914, for which we obtained

$$\left.\begin{array}{rl} \phi = & 5^\circ \ 6' \ 16''\text{N} \\ L - \lambda = & 38 \ 55 \ 56 \ \text{W} \end{array}\right\} \text{For Jupiter,}$$

$$\left.\begin{array}{rl} \phi = & 7^\circ \ 18' \ 20''.7 \ \text{N} \\ L - \lambda = & 39 \ 9 \ 34 \ .6 \ \text{W} \end{array}\right\} \text{For Venus.}$$

In each case the difference, $L - \lambda$, was positive and the respective solar disturbances were to form at the west of the central meridian for the date September $23^d.36$, 1914. Did they really form there at the points having the above coördinates? Observation alone can give the answer and it gives it in no uncertain tone. (By the way, the forecast of this vast solar upheaval was made last August.) In very deed, if we start from a western point determined by either set of coördinates, as given above, and go around from west to east and from east to west according to the latest data regarding the sun's rotation period, we find a glorious exhibition of sunspots in a group crossing Central between the eighth and the ninth of the current month, November, 1914. Numerous examples together with the practical way of working them out may be given in another issue of Popular Astronomy.

Summing up, we have the following facts and conclusions:

1) A straight line from the sun's center to the center of a planet in conjunction with or opposition to another planet, pierces the sun's surface at a well-defined point.

2) Every point on this line has the same celestial longitude and latitude as the center of the planet, for it has the same trigonometric function and the same dihedral angle at either pole of the ecliptic.

3) The heliocentric coördinates of the center of a planet are gathered from data in, say, the American Ephemeris and rendered exact by astronomical interpolation.

4) The coördinates of the point on the sun's surface pierced by the above line, being heliocentric, can be converted into heliographic, by some process or other, preferably by the one we have followed, originally due to Carrington, who applied it to *actual and measured*, instead of to *potential*, sunspots, as we have done.

5) The brand new spot or facula begins to form at the point thus heliographically determined.

6) While the sun rotates from east to west, the disturbance thus formed, goes through a process of formation and decay and nearly always becomes visible at one time or another, and, by actual measurement, can be traced back to its *mathematical* origin.

7) An uniform occurrence of this kind cannot be mere coincidence, but must be the regular effect of a cause which becomes operative at conjunctions and oppositions.

8) From the nature of the effect, the nature of the cause can be inferred. The sunspot is a whirl. Therefore its cause is also a whirl actual or potential. Hence there is a strong pressure to induce the belief that the interplay of solar and planetary electromagnetism is the cause of sunspots.

9) Gravity, as a linear and not a whirling force, should never have been mentioned as a factor of sunspottedness; it has proved a failure and the future is not likely to belie the past.

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Observations of the spots of the sun
by Carrington, Greenwich Observatory.
La Observación solar
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Observatory, University of Santa Clara,
California, U. S. A.

THE PRISMATIC ASTROLABE, A NEW INSTRUMENT FOR DETERMINING LATITUDE AND TIME BY EQUAL ALTITUDES.*

DAVID RINES.†

The method of equal altitudes for the astronomic determination of the observer's position upon the earth's surface leads to results of such surprising accuracy that it has been termed incontestably superior to any other. As the name suggests, this method calls for the observation of celestial bodies in various portions of the heavens, but always at the same altitude, the observation consisting merely in noting the time when this altitude is attained.

As the altitude itself is entirely eliminated from the results in the course of the computation, its exact value, affected by constant errors of graduation, eccentricity, level, collimation, azimuth, flexure, etc., is of no consequence, provided only that it is the same for all stars observed. The local time and the latitude thus obtained, free from systematic error due to these sources, are remarkably precise.

The method itself was introduced by Gauss, who first pointed out its advantages a century ago. Employing a sextant and artificial horizon, this illustrious mathematician, even with such crude apparatus, and with only three stars, obtained a value for latitude, which excited wonder. After Gauss, others experimented with the sextant; but only the brighter stars can be observed with this little instrument. Very few of these can be found at a given altitude within a reasonably short period of time, and the small magnification necessarily employed to permit keeping the star in the field of view is not conducive to sharp observation. Sextant work cannot be relied upon for work of extreme precision.

Experiments were accordingly made with theodolites and other instruments rotatable around a stable vertical axis, and very good results were obtained by careful manipulation; but the artificial horizon was here replaced by some device like the spirit level, and this re-introduced the bugbear of systematic error. The method of equal altitudes, therefore, despite its advantages, though employed extensively at sea, was long neglected on land.

* Reprinted from *Engineering News* for October 8, 1914.

† U. S. Naval Observatory, Washington, D.C.

Recently, the French took hold of the problem, and in their ingenious way solved it by inventing and improving a new instrument, "l' astrolabe à prisme," "the astrolabe with a prism," or the prismatic astrolabe. Of this there are several forms, but the principle in all is the same. Like the sextant, the astrolabe involves the use of an artificial horizon, but it replaces the two separate sextant mirrors by a single equilateral glass prism. The prism is mounted, edges horizontal, with rear face vertical, in front of the object glass of a horizontal telescope rotatable on a vertical axis in a horizontal plane, and the whole—prism, telescope, mercury basin and other appliances—is supported on a tripod like a theodolite.

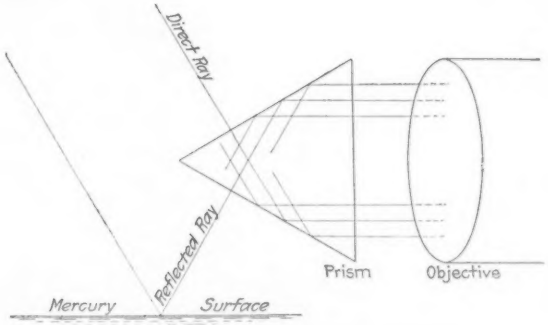


FIG. 1. ELEMENTS OF THE PRISMATIC ASTROLABE.

One face of the prism receives light directly from the star, another from the star's image reflected in the mercury, and the two light rays, after internal reflection, pass through the rear face of the prism to the object glass. Stars are thus observed at a constant altitude of 60°.

For time determination, observations are made in the neighborhood of the prime vertical, where the altitude changes most rapidly; for latitude, near the meridian. As it is easily possible without field illumination to observe stars as faint as the seventh magnitude, a skilful observer may secure 30 to 40 stars in less than an hour, and this number is sufficient to give very good values for both time and latitude. An interesting feature of the astrolabe is that, unlike other instruments, the results obtained, if the prism be well constructed and by employing reasonable care, are almost entirely independent of errors due to maladjustment. The telescope should be perfectly horizontal; so also should the prism edges; and the rear face of the prism should be vertical. If, however, the prism edges, for example, are not horizontal, the skilled observer will recognize this fact when he perceives the motion of the star in the field of view and a slight touch of a screw

eliminates the inconvenience; indeed, this adjustment is generally effected on every star.

The one important adjustment—and even that is not absolutely essential—is the perpendicularity of the rear face of the prism to the axis of the telescope, which is easily affected by aid of a simple auxiliary device. If the adjustments are not perfect, the only error involved is in the observed altitude which, instead of being 60°, may be some larger or smaller quantity; but if care is taken to make all observations in the same portion of the field, and in the same way, this quantity will be the same in all positions of the instrument. All stars will be observed at the same altitude, and the resulting latitude and local time will be unaffected. With the newer type of prismatic astrolabe, permitting temporary field illumination, this condition is easily fulfilled.

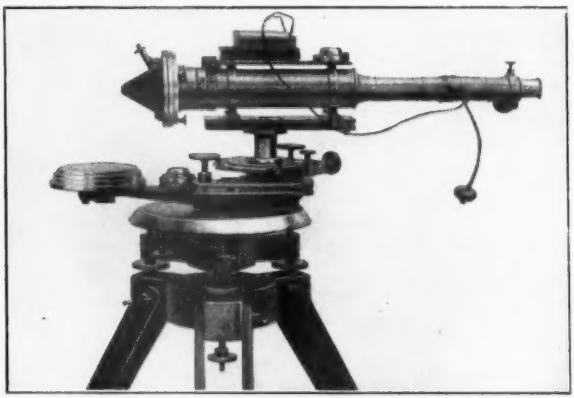


FIG. 2. PRISMATIC ASTROLABE FOR DETERMINING LATITUDE AND TIME BY THE METHOD OF EQUAL ALTITUDES.

There are no instrumental constants to be determined, and consequently there are no systematic errors introduced by such constants. There are no circle measures, with the danger of reading them incorrectly. There are no errors of nadir, pointing, thread inclination, pivots, etc., such as affect observations with other instruments. In fact, nearly all constant errors, affecting all observations alike, are eliminated. There is danger of systematic error introduced by the personal equation in noting the times of observation, but almost all other errors are of the accidental class, and may be eliminated by increasing sufficiently the number of observed stars.

The manipulation of the instrument is simple, rapid and easy. The French employ one or two assistants, but a single observer can work just as easily and quickly without aid. Guided by a previously pre-

pared list of stars containing approximate times and azimuths, the observer first sets the telescope in azimuth, then seating himself at the eye end, watches the star and its reflected image enter the field of view from opposite directions. He touches a screw, perhaps, to cause the images to change slightly their relative positions, or to bring their vertical line nearer the center of the field. As the images draw closer in their approach toward each other, he concentrates his attention and at the moment of coincidence makes a record of the time, either by the eye and ear method, or by the chronograph and key. In this record is comprised the whole observation.

The computations, both preliminary to and succeeding the observations, are long and tedious. An hour's observing list requires many hours of preparation and subsequent computation. The labor of preparing the observing list may be considerably shortened by tables and other aids; and the final computations, too, may be made more easy by tables and graphic processes. The fact, nevertheless, remains that the computations are time consuming. In view of the high precision attainable, this objection should carry but little weight, particularly when it is remembered that the computations may be made at one's leisure, long after the observations have been completed.

The instrument is comparatively inexpensive, it is light and portable, and requires no previously established stable foundation, but may be set up in a few minutes. These considerations should recommend it particularly to geographers, explorers, surveyors and other travelers who seek accuracy, yet do not wish to encumber themselves with the comparatively heavy portable transit and accompanying chronograph. For the very finest kinds of longitude work, however, owing to the personal equation, the astrolabe should be looked upon with suspicion. Yet it should be remarked that it has been used side by side with portable astronomic transits of the best known types, and the results obtained by two different kinds of instrument have been wonderfully close.

The prismatic astrolabe has been employed by the French on boundary and other survey work in their colonies, in the measurement of a meridian arc in Ecuador, and more recently in important wireless longitude determinations. It was used in the spring of 1913 in the preliminary operations attending the determination of the difference of longitude between Washington and Paris.

The astrolabe may be employed for absolute longitudes by observing equal altitudes of stars and of the moon. It can advantageously replace the portable transit in much of the longitude work now carried on in this country, and would result in considerable saving. Among other

applications, it may be employed at fixed observatories to determine star positions. Our astronomers and engineers should give it a trial.

For an exhaustive discussion, the reader is recommended to A. Claude et L. Duencourt, "Description et Usage de L' Astrolabe à Prisme."

REMARKS ON METEOR OBSERVING AND THE GEMINID METEORS OF DECEMBER 1914.

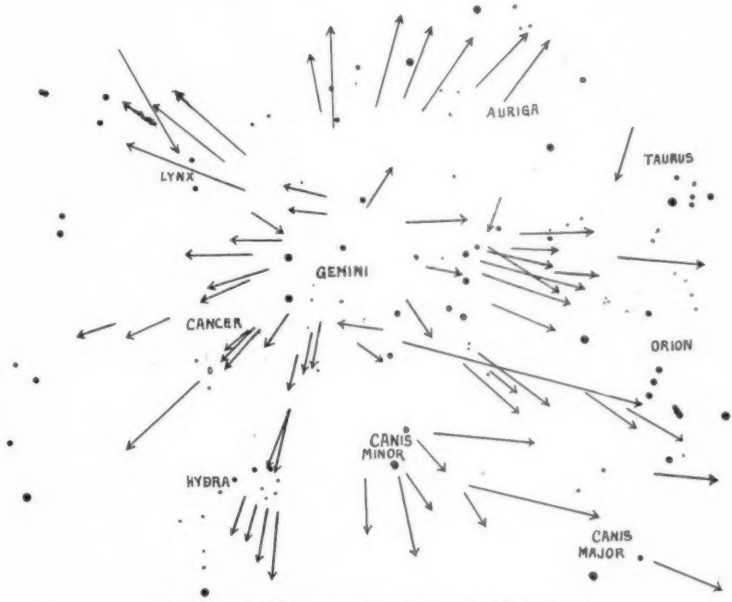
NELS BRUSETH.

A very interesting branch of astronomical work for amateurs is meteor observing. Under the able direction of Chas. P. Olivier, director of the American Meteor Society and as a member of the Society for Practical Astronomy, I have spent some time in this work and during the last two years have observed, recorded particulars and plotted paths, for about one thousand meteors. These and the work of other members of the A. M. S. are included in a recent publication of the Leander McCormick Observatory, University of Virginia, titled "126 Parabolic Orbits of Meteor Streams deduced from observations of over 2,800 meteors." It is the work of Mr. Olivier. I count my copy a very valuable addition to my library.

During my whole experience with meteors I found the conditions most favorable for observing during a stay of two months in the Cascade Mountains near Index, Washington. Here, while camping out on the mountains at elevations of from six to seven thousand feet, during nights when the hourly rate is usually from 8 to 12 per hour, I observed 20 and 30 meteors. The brilliant skies made visible a great number of low magnitude meteors that otherwise would have been lost. There are occasionally very clear skies along Puget Sound, Washington, but after midnight work is often interrupted by a haze that seems to drift inland from the waters. Here in southwestern California we have a great number of clear nights during the whole year and conditions for meteor observing as well as other astronomical work are very favorable.

I commend meteor observing to amateurs. Even though you may have a great interest in some other line or branch, such as variable star work, you will find it a pleasant relaxation from your other work. Try one night per month or when the maximum of some shower or radiant is at hand. Send the results to the director of the American Meteor Society.

The following is a list of observations of meteors, mainly Geminids, December 1914 and general results. The paths were drawn or plotted on two separate maps of different projection and transferred to a third map of composite projection. Nearly all possible Geminids were lined up from stars back of path, in this case in Gemini. On original maps and in reports the meteors were numbered but on accompanying map numbers are omitted.



THE GEMINID METEORS ON DECEMBER 11, 1914, 8^h-13^h.

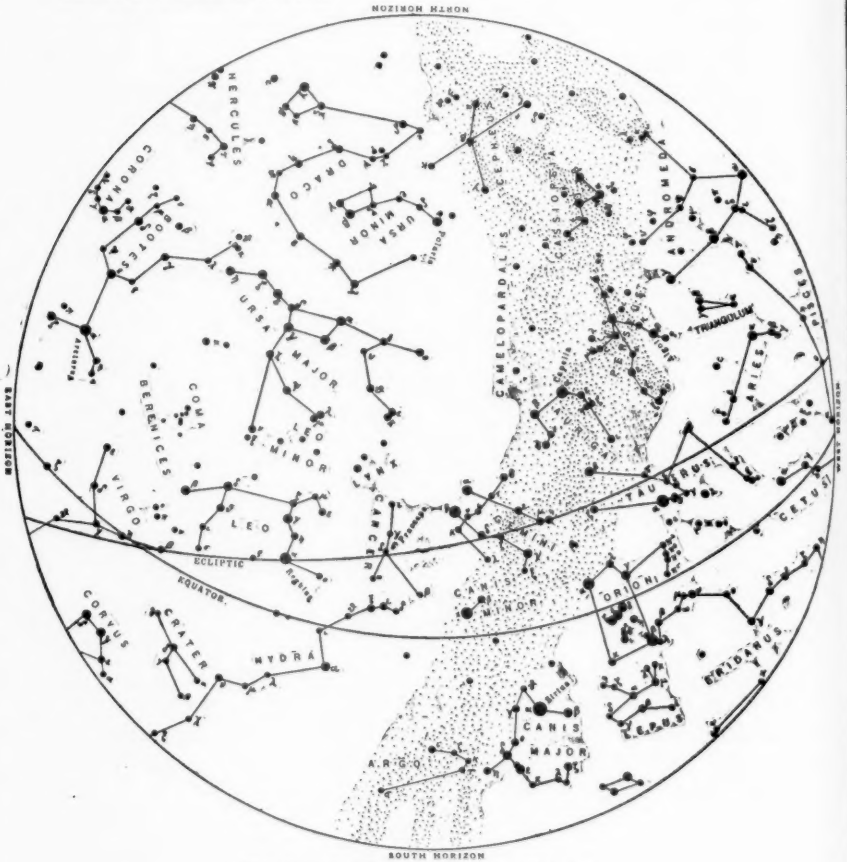
During the 11th and 12th there were several meteors indicating radiants in Canis Minor and Hydra. A number of the meteors were of the flash variety, exceedingly swift and hard to plot. The average meteor was short and swift and white in color, with occasionally a tinge of blue. Following is a general summary.

Dec. 10. One hour, $9^h\ 20^m$—$10^h\ 20^m$. Clear sky; 9 meteors; possibly 4 Geminids.
Dec. 11. Five hours, 18^h—13^h. Clear sky; 112 meteors; possibly 80 Geminids. Hourly rate: 1st hour 10, 2d 15, 3d 24, 4th 24, 5th 39.
Dec. 12. Two hours, 14^h—16^h, Clear sky; 73 meteors; possibly 45 Geminids. Hourly rate: 1st hour 36, 2d 37.
Dec. 19. Two hours, $12^h\ 14^h$. Clear sky; 26 meteors.
Dec. 21. One hour fifteen minutes. Clear sky; slight moonlight; 4 meteors.

Los Angeles, Cal.

PLANET NOTES FOR MARCH, 1915.

The sun will move northeastward from the constellation Aquarius, crossing the equator on Sunday morning March 21, into the constellation Pisces. The crossing of the equator by the sun marks the time of the vernal equinox and the almanac time of the beginning of spring.



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

The phases of the moon for this month are as follows:

Full Moon	Mar.	1	at 1 P.M.	C.S.T.
Last Quarter		8	" 6 A.M.	"
New Moon		15	" 2 P.M.	"
First Quarter		23	" 5 P.M.	"
Full Moon		30	" 12 P.M.	"

This month, like January, is unusual in that it has two full moons, the intervening month having had none.

Mercury will be moving rapidly west from the sun at the beginning of the month. On the twentieth of the month it will reach a point of greatest elongation west. On and near this date it will rise about two hours before the sun and will be visible in the morning sky.

Venus, although it is moving towards the sun, will still be conspicuous in the morning sky. Because of its great brilliancy it may be seen with the naked eye up to the time of sunrise. It will be receding from the earth and will be becoming fainter. Near the end of the month it will be about 100,000,000 miles from the earth.

Mars will not yet be far enough from the sun to be studied. By the end of the month it will rise a little more than an hour before the sun. It will be approaching the earth and therefore be getting brighter. At the end of the month it will, however, still be about 200,000,000 miles from the earth.

Jupiter will be too near the sun at the beginning of the month to be seen. By the end of the month it will again appear as a morning star on the eastern horizon just before sunrise. It will be south of the equator and moving northward.

Saturn will be most favorably situated of all the planets this month. It will be in quadrature, 90° east of the sun, on March 16. On and near this date therefore it will be near the meridian at sunset. This spectacular object may therefore be well observed during this month.

Uranus, being so far south and also rather near the sun, will not be favorable for observation. By the end of the month it will rise a few hours before the sun.

Neptune, like Saturn, will be very well situated during the month. By the end of the month it will be near a position of quadrature, 90° east of the sun. It will cross the meridian shortly after sunset.

Occultations Visible at Washington.

Date 1915	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Mar. 4	83 Virginis	5.6	9 6	136	9 58	283	0 52
20	18 Tauri	5.6	10 53	49	11 36	303	0 43
20	*q* Tauri	4.3	11 2	152	11 23	199	0 21
20	21 Tauri	5.8	11 9	123	11 51	229	0 42
25	9 Cancri	6.2	6 0	100	7 26	302	1 26
25	49 B Cancri	6.0	14 49	157	15 25	247	0 36
28	37 Sextantis	6.3	9 31	209	9 45	230	0 14
29	*v* Leonis	4.5	9 44	164	10 45	275	1 1
31	75 Virginis	5.6	14 53	98	16 0	320	1 7

Saturn's Satellites for March 1915.

CENTRAL STANDARD TIME.

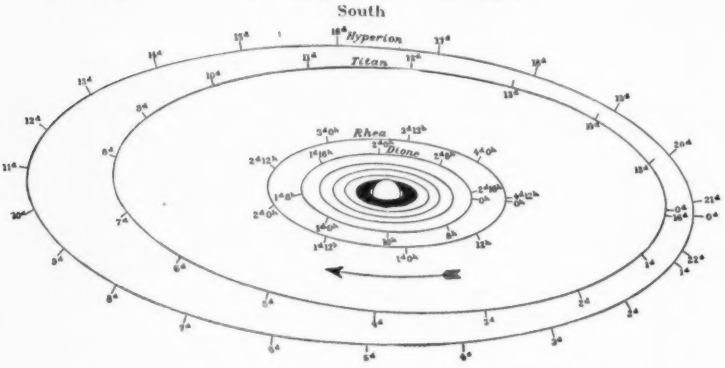
E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$

	h		h		h		h
Mar. 1	12.1 E	Mar. 4	8.0 E	Mar. 10	11.0 W	Mar. 12	8.2 W
2	10.8 E	5	6.6 E	11	9.6 W	13	6.8 W
3	9.4 E	9	12.3 W				

II. Enceladus. Period $1^d\ 8^h.8$

		h			h			h			h
Mar.	1	4.1 E	Mar.	9	9.5 E	Mar.	17	14.8 E	Mar.	25	20.2 E
	2	13.0 E		10	18.4 E		18	59.7 E		27	5.1 E
	3	21.9 E		12	3.3 E		20	8.6 E		28	14.0 E
	5	6.8 E		13	12.2 E		21	17.5 E		29	22.9 E
	6	15.7 E		14	21.1 E		23	2.4 E		31	7.8 E
	8	.6 E		16	5.9 E		24	11.3 E			



Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, December 20, 1914, as seen in an Inverting Telescope.

III. Tethys. Period $1^d\ 21^h.3$

		h			h			h			h
Mar.	2	13.7 E	Mar.	10	2.9 E	Mar.	17	16.2 E	Mar.	25	5.5 E
	4	11.0 E		12	.3 E		19	13.5 E		27	2.8 E
	6	8.3 E		13	21.6 E		21	10.9 E		29	0.2 E
	8	5.6 E		15	18.9 E		23	8.2 E		30	21.5 E

IV. Dione. Period $2^d\ 17^h.7$

Mar.	2	4.7 E	Mar.	10	9.9 E	Mar.	18	15.0 E	Mar.	26	20.1 E
	4	22.4 E		13	3.6 E		21	8.7 E		29	13.9 E
	7	16.1 E		15	21.3 E		24	2.4 E			

V. Rhea. Period $4^d\ 12^h.5$

Mar.	2	4.6 E	Mar.	11	5.5 E	Mar.	20	6.5 E	Mar.	29	7.5 E
	6	17.1 E		15	18.0 E		24	19.0 E			

VI. Titan. Period $15^d\ 23^h.3$

Mar.	3	12.8 S	Mar.	7	15.1 E	Mar.	15	12.3 W	Mar.	23	14.5 E
				11	15.1 I		19	12.0 S			

VII. Hyperion. Period $21^d\ 7^h.6$

Mar.		5.7 W	Mar.		16.2 E	Mar.		21.1 I	Mar.		27.0 W
		11.5 S									

VIII. Japetus. Period $79^d\ 22^h.1$

Mar. $19^d.6$ S

IX. Phoebe. Period $580^d\ 2^h.9$

		α Ph.−α Sat.			δ Ph.−δ Sat.			α Ph.−α Sat.			δ Ph.−δ Sat.		
		m	s		′	″		m	s		′	″
Mar.	2	−1	58.0		−3	54	Mar. 18	−1	37.0		−3	39
	6	1	53.3		3	52	22	1	31.0		3	33
	10	1	48.2		3	49	26	1	24.6		3	26
	14	−1	42.8		−3	44	30	−1	18.0		−3	19

VARIABLE STARS.

Four New Variables.—In *A.N.* 4770 four new variable stars are announced with temporary names and positions in 1900 as follows:

		α	δ
		h m	° ′
(1)	92.1914 Cephei	22 2.3	+62 0
(2)	93.1914 Cephei	21 59.8	+62 45
(3)	94.1914 Cephei	22 6.9	+62 38
(4)	95.1914 Cephei	21 50.4	+61 28.5

They, as is seen from the above, are all in the same constellation Cepheus. They were discovered by C. R. D'Esterre and are all faint, having a range of variation of the order of from the twelfth to the fifteenth magnitudes. Those for which a tentative period can be given seem to be of long period variation.

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1915.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn.
	h m	° ′			h m	° ′	
S Sculptoris	0 10.3	−32 36	7.8 *i*	T Orionis	5 30.9	− 5 32	10.6*d*
X Androm.	10.8	+46 27	<11.0	U Aurigae	35.6	+31 59	<11.0
T Androm.	17.2	+26 26	9.8	V Camelop.	49.4	+74 30	13.4*a*
T Cassiop.	17.8	+55 14	9.0*d*	U Orionis	49.9	+20 10	11.3*d*
R Androm.	18.8	+38 1	<11.0	Z Aurigae	53.6	+53 18	9.8 *i*
S Ceti	19.0	− 9 53	8.2	X Aurigae	6 4.4	+50 15	9.4 *i*
Y Cephei	31.3	+79 48	9.9 *i*	U Lyncis	31.8	+59 57	11.4
U Cassiop.	40.8	+47 43	10.6 *i*	S Lyncis	35.9	+58 0	<13.0
RR Androm.	45.9	+33 50	9.5	R Lyncis	53.0	+55 28	10.2 *i*
RV Cassiop.	47.1	+46 53	8.6	R Gemin.	7 1.3	+22 52	9.4*d*
W Cassiop.	49.0	+58 1	11.7	R Can. Min.	3.2	+10 11	9.4*d*
S Cassiop.	1 12.3	+72 5	11.8	S Can. Min.	27.3	+ 8 32	7.6 *i*
S Piscium	12.4	+ 8 24	10.2	U Can. Min.	35.9	+ 8 37	8.6
R Piscium	25.5	+ 2 22	9.0*d*	T Gemin.	43.3	+23 59	8.0
X Cassiop.	49.8	+58 46	9.4	R Leo. Min.	9 39.6	+34 58	7.4
U Persei	53.0	+54 20	7.7	R Leonis	42.2	+11 54	5.7
R Arietis	2 10.4	+24 35	<11.0	R Urs. Maj.	10 37.6	+69 18	11.6 *i*
o Ceti	14.3	− 3 26	5.4 *i*	T Urs. Maj.	12 31.8	+60 2	7.2
S Persei	15.7	+58 8	9.8 *i*	R Virginis	33.4	+ 7 32	9.0*d*
R Ceti	20.9	− 0 38	<11.0	S Urs. Maj.	39.6	+61 38	6.6*d*
RR Persei	21.7	+50 49	12.4	R Can. Ven.	13 44.6	+40 2	9.2 *i*
U Ceti	28.9	−13 35	10.0 *i*	U Urs. Min.	14 15.1	+67 15	8.8 *i*
R Trianguli	31.0	+33 50	10.2*d*	S Bootis	19.5	+54 16	9.0*d*
W Persei	43.2	+56 34	10.6	R Camelop.	25.1	+84 17	8.4
Y Persei	3 20.9	+43 50	8.0	V Bootis	25.7	+39 18	9.0 *i*
R Persei	23.7	+35 20	<13.0	R Bootis	32.8	+27 10	<11.0
V Eridani	59.8	−16 0	9.6	S Urs. Min.	33.4	+78 58	11.4*d*
W Tauri	4 22.2	+15 49	12.0	R Draconis	16 32.4	+66 58	7.7*d*
R Tauri	22.8	+ 9 56	11.6	RV Herculis	56.8	+31 22	10.1
S Tauri	23.7	+ 9 44	<10.0	T Herculis	18 5.3	+31 0	<11.0*d*
X Camelop.	32.6	+74 56	10.0 *i*	W Lyrae	11.5	+36 38	8.0
RX Tauri	32.8	+ 8 9	9.8 *i*	RW Lyrae	42.1	+43 32	<13.0
V Tauri	46.2	+17 22	9.6 *i*	R Scuti	42.2	− 5 49	5.5
R Leporis	55.0	−14 57	8.2	R Aquilae	19 1.6	+ 8 5	7.1*d*
V Orionis	5 0.8	+ 3 58	<11.0	TZ Cygni	13.4	+50 0	10.6
R Aurigae	9.2	+53 28	9.0 *i*	U Lyrae	16.6	+37 42	11.2
W Aurigae	20.1	+36 49	11.0*d*	TY Cygni	29.8	+28 6	<13.0
S Orionis	24.1	− 4 46	10.1*d*	R Cygni	34.1	+49 58	<12.0

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1915—Continued.

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900.	Dec. 1900.	Magn.
	h m	° ′			h m	° ′	
RT Cygni	19 40.8	+48 32	10.9*d*	T Cephei	21 8.2	+68 5	6.9*d*
X Aquilae	46.5	+ 4 13	<13.0	S Cephei	36.5	+78 10	8.6 *i*
χ Cygni	46.7	+32 40	5.4*d*	RU Cygni	37.3	+53 52	9.4*d*
Z Cygni	58.6	+49 46	12.6	RR Pegasi	40.0	+24 33	9.2
SY Aquilae	20 2.3	+12 39	<12.0	V Pegasi	56.0	+ 5 38	<13.0
S Cygni	3.4	+57 42	<13.0	T Pegasi	22 4.0	+12 3	<13.0
S Aquilae	7.0	+15 19	11.2	Y Pegasi	6.8	+13 52	10.2
SX Cygni	11.6	+30 46	<13.0	RS Pegasi	7.4	+14 4	10.6
U Cygni	16.5	+47 35	7.8*d*	R Lacertae	38.8	+41 51	12.2
ST Cygni	29.9	+54 38	9.8	S Aquarii	51.8	−20 53	12.9
Y Delphini	36.9	+11 31	<13.0	R Pegasi	23 1.6	+10 0	8.2
V Cygni	38.1	+47 47	10.8*d*	V Cassiop.	7.4	+59 8	11.6 *i*
S Delphini	38.5	+16 44	11.9	S Pegasi	15.5	+ 8 22	11.5
T Delphini	40.7	+16 2	13.0	ST Androm.	33.8	+35 13	10.5*d*
V Delphini	43.2	+18 58	<12.0	R Aquarii	38.6	−15 50	9.9*d*
T Aquarii	44.7	− 5 31	12.0	Z Cassiop.	39.7	+56 2	<13.0
X Delphini	50.3	+17 16	10.0*d*	R Cassiop.	53.3	+50 50	8.6*d*
R Vulpeculae	59.9	+23 26	10.8*d*	Z Pegasi	55.0	+25 21	9.7
TW Cygni	21 1.8	+29 0	12.9*d*	SV Androm.	59.2	+39 33	12.1*d*

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—L. Barbour, A. T. Bolfing, T. C. H. Bouton, A. B. Burbeck, H. O. Eaton, F. H. Hay, S. C. Hunter, M. W. Jacobs, Jr., J. B. Lacchini, O. Mach, C. Y. McAteer, C. S. Mundt, W. T. Olcott, D. B. Pickering, C. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E Woods, and A. S. Young.

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. March.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7				24 10				
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	8 5;	16 8;	24 12					
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	1 13;	9 7;	17 1;	24 19				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		13 2;	27 22					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 18;	10 17;	18 15;	26 14				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	8 12;	16 8;	24 3;	31 22				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	2 21;	10 4;	17 11;	24 17				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	4	20						
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	8 10;	17 0;	25 14					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1		11 9;	22 12					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	2 10;	14 1;	25 16					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	7 9;	15 1;	22 16;	30 8				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	3 6;	13 9;	23 13					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	3 20;	11 13;	19 6;	27 0				
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	6 0;	11 13;	22 15;	28 3				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	2 18;	10 7;	17 21;	25 10				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		12 14						
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	6 0;	13 5;	20 10;	27 15				
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	7 22;	15 20;	23 18;	31 16				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. March.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 21;	14 1;	24 5					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		16 4						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	8 17;	16 15;	24 14					
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	6 15;	13 8;	20 0;	26 17				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	1 20;	11 2;	20 9;	29 16				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	6 23;	15 16;	24 10					
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0		10						
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	1 15;	8 10;	21 23;	28 18				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 6;	11 21;	25 2;	31 16				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	5 15;	15 7;	24 23					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	9 22;	17 22;	25 21					
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	5 4;	11 22;	18 16;	25 9				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4 0;	9 20;	21 11;	27 7				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4 0;	8 16;	13 9;	22 18				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	9 14;	26 21						
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	3 10;	11 14;	19 19;	28 0				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	7 11;	14 12;	21 12;	28 13				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	8 8;	16 13;	24 18					
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	6 10;	11 22;	22 21;	28 9				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	3 0;	10 13;	18 2;	25 15				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	7 1;	14 11;	21 21;	29 7				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	2 20;	9 14;	23 4;	29 22				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	5 10;	11 18;	24 10;	30 18				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	2 3;	11 21;	21 15;	31 9				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	4 0;	12 21;	21 17;	30 14				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	3 20;	9 21;	15 23;	28 2				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	2 7;	9 7;	23 7;	30 8				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		19 0						
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	3 1;	10 16;	18 6;	25 20				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 11;	10 5;	21 18;	27 13				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 4;	9 22;	23 10;	30 4				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	2 13;	12 21;	23 5					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	4 23;	11 0;	23 2;	29 2				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 19;	9 22;	22 4;	28 8				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	3 4;	9 3;	21 0;	26 23				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	9 4;	18 6;	27 8					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 15;	8 16;	22 17;	29 18				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	3 8;	10 8;	24 8;	31 8				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	3 8;	11 8;	19 7;	27 7				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	6 11;	14 4;	21 20;	29 13				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	4 3;	11 8;	18 12;	25 16				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	3 15;	12 0;	20 9;	28 19				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3 9;	9 17;	16 1;	28 16				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	5 16;	22 1						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	3 21;	8 7;	17 4;	26 1				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	6 6;	12 23;	19 17;	26 10				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	6 9;	13 2;	19 19;	26 12				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	5 11;	20 4						
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	2 22;	10 19;	18 16;	26 12				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	4 8;	11 6;	18 3;	25 0				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	1 18;	11 12;	16 9;	26 2				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	8 16;	17 8;	26 0					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	4 18;	10 3;	20 21;	31 14				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	7 10;	18 7;	29 4					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	1 11;	7 22;	20 18;	27 4				
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	1 6;	11 5;	16 5;	26 4				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4 20;	10 7;	21 4;	26 14				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 20;	12 3;	24 17;	31 0				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	3 7;	15 10;	27 14					
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	5 12;	10 12;	20 11;	30 11				

Minima of Variable Stars of Short Period.

[Calculated by Elva Utzinger and C. D. Hibbard at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8								
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	1 5;	8 21;	16 13;	24 5				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	5 23;	13 9;	20 20;	28 6				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 3;	14 14;	22 2;	29 13				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6 20;	12 22;	25 4;	31 7				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	5 2;	12 5;	19 9;	26 12				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	7 1;	13 22;	20 19;	27 16				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 12;	13 16;	20 20;	28 0				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	5 21;	14 15;	23 10					
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	4 7;	12 5;	20 4;	28 3				
RX Cassiop.	58.8	+67 11	8.6— 9.1	32 07.6			24 3					
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4 4;	9 22;	21 9;	27 3				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3 7;	10 2;	23 16;	30 11				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 1;	8 23;	16 20;	24 18				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8 10;	16 17;	25 0					
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	6 14;	14 11;	22 9;	30 6				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	2 6;	15 11;	28 16					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	2 15;	12 2;	21 13;	30 23				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		11 10;	23 20					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	1 13;	8 5;	21 13;	28 5				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	3 16;	14 14;	20 1;	30 22				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	6 7;	12 8;	24 9;	30 9				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	7 5;	15 21;	24 13					
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	8 2;	18 11;	28 21					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4 19;	12 19;	20 19;	28 20				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	6 13;	12 7;	23 18;	29 11				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	5 5;	10 19;	22 0;	27 15				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	5 5;	13 10;	21 15;	29 20				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	3 15;	13 6;	20 21;	28 12				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	1 4;	13 9;	25 14					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	5 0;	12 4;	19 8;	26 12				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	8 6;	17 8;	26 11					
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	6 16;	15 23;	25 6					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	3 15;	13 13;	23 11					
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	5 10;	13 20;	22 5;	30 15				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1 5;	7 15;	20 12;	26 22				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	5 18;	13 1;	20 7;	27 14				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	1 19;	9 22;	18 1;	26 4				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6		10 8;	19 20;	29 7				
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8		6 8;	15 11;	24 14				
S Antliae	27.9	−28 11	6.3— 6.8	0 07.8	6 20;	13 8;	19 20;	26 7				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	6 3;	12 1;	23 22;	29 20				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	1 12;	9 22;	18 8;	26 19				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	9 0;	18 7;	27 13					
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	6 23;	13 13;	20 4;	26 18				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	4 0;	12 19;	21 14;	30 10				
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	5 23;	13 7;	20 15;	27 23				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3 12;	10 7;	23 21;	30 16				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	4 14;	12 2;	19 14;	27 2				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	7 15;	15 1;	22 12;	29 22				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	5 5;	12 5;	19 4;	26 4				
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	2 5;	9 3;	16 1;	22 22				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	8 3;	16 13;	24 23					

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 March.
	h m	° ′		d h	d h d h d h d h
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	8 12; 16 4; 23 20; 31 12
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	6 5; 13 13; 20 21; 28 5
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	8 19; 17 1; 25 7
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	8 13; 17 9; 26 6
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	3 17; 14 19; 24 12
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	6 12; 13 8; 20 3; 26 22
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	4 4; 12 13; 20 23; 29 8
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 11; 7 15; 19 22; 26 2
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	3 16; 10 21; 18 2; 25 7
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	7 19; 15 4; 22 13; 29 22
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 0; 16 4; 24 8
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	3 1; 10 14; 18 3; 25 16
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	2 12; 10 6; 18 0; 25 17
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	7 19; 15 19; 23 18; 31 18
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	3 22; 12 10; 20 23; 29 11
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	7 10; 16 18; 26 2
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	8 0; 18 8; 28 16
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	2 21; 10 3; 24 15; 31 21
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	6 10; 13 8; 20 6; 27 3
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	5 11; 20 14
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 5; 9 11; 17 18; 26 0
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	3 8; 12 5; 21 3; 30 0
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	8 7; 16 13; 24 22
RR Draconis	40.8	+62 34	9.3—13	2 19.9	2 21; 11 8; 19 20; 28 8
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2 15; 9 7; 15 22; 29 5
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	3 1; 15 23; 28 20
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	3 5; 12 18; 22 7; 31 20
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	6 16; 14 6; 21 20; 29 9
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	3 1; 10 6; 24 15; 31 20
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	4 14; 13 13; 22 11; 31 10
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	4 17; 11 12; 25 0; 31 18
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	6 12; 13 21; 21 5; 28 14
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	3 14; 14 1; 19 7; 29 19
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	3 22; 10 11; 23 12; 30 0
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	4 0; 10 0; 16 1; 28 1
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	7 10; 14 2; 20 17; 27 8
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1 2; 10 5; 19 9; 28 12
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	6 19; 15 5; 23 15
RW Capric.,	12.2	−17 59	8.8—10.6	3 09.4	2 13; 9 8; 22 21; 29 16
UW Cygni	19.6	+42 55	10.5—13	3 10.8	6 5; 13 2; 20 0; 26 21
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	11 7
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	10 12; 20 2; 29 17
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	8 20; 18 1; 27 6
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	7 15; 15 3; 22 14; 30 2
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	2 2; 7 22; 19 15; 31 8
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	3 0; 13 3; 23 5
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	7 10; 14 19; 22 4; 29 13
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	3 2; 12 18; 22 11
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	1 17; 9 14; 17 11; 25 8
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	7 13
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 18; 13 21; 24 1
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	3 6; 13 14; 23 23; 29 4
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	1 13; 6 23; 12 10; 23 7
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	1 13; 9 20; 18 3; 26 10
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	1 10; 8 23; 24 1; 31 14
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	1 9; 9 15; 17 20; 26 22

Designation of Recently Discovered Variable Stars.

[From *Astronomische Nachrichten* No. 4757. This continues the list from *A. N.* 4669 published in POPULAR ASTRONOMY No. 210, December 1913.]

No.	Prov. Des. A. N.	Name	Position 1900 R. A. h m s	Decl. ° ′	Magnitude Max. m	Min. m	
1	31.1913	V Trianguli	1 26 9	+29 51.5	10.5	11.8	ph
2	87.1911	UV Persei	2 3 16	+56 42.8	11	<16	ph
3	21.1912	UW Persei	2 5 26	+56 37.8	13.5	16.5	ph
4	6.1913	UX Persei	2 6 6	+57 37.6	9.9	11.2	v
5	7.1913	UY Persei	2 27 0	+58 26.5	9.8	11.5	ph
6	46.1901	W Horologii	2 41 10	−54 43.4	9.1	10.4	ph
7	41.1906	X Horologii	2 45 6	−59 28.2	8.1	9.4	ph
8	5.1913	Z Arietis	3 2 16	+26 36.3	11	<14.0	ph
9	23.1911	UZ Persei	3 13 56	+31 39.5	8½	9½	ph
10	8.1913	VV Persei	3 19 42	+49 23.2	10.6	<12.3	ph
11	11.1913	VW Persei	3 22 24	+44 3.1	10.6	<14.0	ph
12	206.1907	RY Eridani	3 54 27	−17 30.9	10.0	10.9	ph
13	27.1914	TZ Tauri	3 57 4	+16 23.9	11½	13½	v
14	25.1911	TX Tauri	4 2 4	+26 19	10½	11½	ph
15	4.1913	TY Tauri	4 29 2	+15 3.3	11.0	11.6	v
16	213.1907	UX Orionis	4 59 31	− 3 56.0	9.5	<10.5	ph
17	77.1907	X Pictoris	5 2 43	−53 16.6	9.4	10.5	ph
18	81.1907	Y Pictoris	5 8 18	−45 41.9	9.0	10.0	ph
19	116.1904	UY Orionis	5 27 5	− 5 0.7	10.0	11.0	ph
20	36.1904	UZ Orionis	5 27 53	− 5 44.0	14.1	<15.5	ph
21	19.1913	VV Orionis	5 28 27	− 1 13.6	5.2	5.6	ph
22	37.1904	VW Orionis	5 28 27	− 5 26.1	14.5	<15.1	ph
23	38.1904	VX Orionis	5 28 37	− 4 47.6	14.0	15.0	ph
24	40.1904	VY Orionis	5 28 40	− 5 5.7	13.3	14.6	ph
25	90.1904	VZ Orionis	5 28 51	− 5 35.3	13.0	14.0	ph
26	45.1904	WW Orionis	5 29 9	− 5 41.1	12.9	14.0	ph
27	46.1904	WX Orionis	5 29 12	− 5 17.9	12.9	14.2	ph
28	91.1904	WY Orionis	5 29 15	− 5 36.3	13.1	14.2	ph
29	49.1904	WZ Orionis	5 29 29	− 5 35.0	13.5	14.8	ph
30	51.1904	XX Orionis	5 29 42	− 6 9.6	13.4	14.5	ph
31	54.1904	XY Orionis	5 29 47	− 5 50.1	14.2	15.5	ph
32	55.1904	XZ Orionis	5 29 49	− 5 14.8	14.2	15.5	ph
33	56.1904	YY Orionis	5 29 54	− 6 2.1	11.8	12.8	ph
34	93.1904	YZ Orionis	5 29 58	− 5 7.5	—	—	—
35	40.1903	ZZ Orionis	5 30 1	− 5 50.8	12.5	14.0	ph
36	41.1903	AA Orionis	5 30 16	− 5 50.6	12.1	13.0	ph
37	64.1904	AB Orionis	5 30 20	− 5 47.2	12.7	13.7	ph
38	180.1904	AC Orionis	5 30 21	− 5 27.8	15.2	16.5	ph
39	181.1904	AD Orionis	5 30 23	− 5 26.5	14.0	16.6	ph
40	—	AE Orionis	5 30 23	− 5 25.5	12.6	13.3	ph
41	182.1904	AF Orionis	5 30 24	− 5 27.2	11.9	16.1	ph
42	43.1903	AG Orionis	5 30 27	− 5 38.8	12.9	14.0	ph
43	69.1904	AH Orionis	5 30 30	− 5 13.7	11.1	12.5	ph
44	70.1904	AI Orionis	5 30 32	− 5 15.0	11.8	13.2	ph
45	71.1904	AK Orionis	5 30 32	− 5 29.6	10.7	11.3	ph
46	72.1904	AL Orionis	5 30 34	− 4 59.1	13.2	14.3	ph
47	73.1904	AM Orionis	5 30 40	− 5 25.5	13.0	13.6	ph
48	74.1904	AN Orionis	5 30 47	− 5 32.1	10.3	11.0	ph
49	75.1904	AO Orionis	5 30 47	− 5 9.7	14.0	<15.2	ph
50	102.1904	AP Orionis	5 30 51	− 5 32.0	12.9	13.9	ph
51	109.1910	AQ Orionis	5 30 57	− 5 32.7	12.6	13.7	ph
52	78.1904	AR Orionis	5 30 58	− 5 8.0	12.3	13·3	ph
53	44.1903	AS Orionis	5 30 58	− 4 51.3	13.3	<15.0	ph
54	45.1903	AT Orionis	5 30 59	− 6 54.7	14.5	15.4	ph
55	105.1904	AU Orionis	5 31 5	− 6 1.3	13.0	<14.0	ph

v = visual magnitude. ph = photographic magnitude.

Designation of Recently Discovered Variable Stars—Continued.

No.	Prov. Des. A. N.	Name	Position 1900 R. A. h m s	Decl. ° ′	Magnitude Max. m	Min. m	
56	46.1903	AV Orionis	5 31 8	— 6 46.4	13.0	14.9	ph
57	83.1904	AW Orionis	5 31 13	— 6 33.3	13.7	<15.0	ph
58	81.1904	AX Orionis	5 31 14	— 6 18.2	12.8	13.9	ph
59	82.1904	AY Orionis	5 31 16	— 6 52.0	14.4	<15.4	ph
60	85.1901	AZ Orionis	5 31 22	— 5 15.6	11.8	<14	ph
61	84.1904	BB Orionis	5 31 28	— 6 21.5	13.0	14.5	ph
62	85.1904	BC Orionis	5 31 43	— 5 30.0	13.5	14.6	ph
63	86.1904	BD Orionis	5 31 46	— 6 23.1	12.1	13.3	ph
64	87.1904	BE Orionis	5 32 9	— 6 37.1	11.5	<14.8	ph
65	120.1904	BF Orionis	5 32 21	— 6 38.6	10.4	11.7	v
66	4.1906	BG Orionis	5 34 25	— 2 43.6	15.0	16.3	ph
67	89.1904	BH Orionis	5 35 13	— 6 18.9	12.2	13.2	ph
68	83.1907	R Mensae	5 46 2	—75 17.3	9.5	10.6	ph
69	87.1907	AB Carinae	6 34 23	—55 46.7	9.5	10.5	ph
70	89.1907	AC Carinae	7 5 8	—58 13.4	8.2	9.3	ph
71	27.1913	VX Aurigae	7 21 35	+41 10.4	9.5	12.5	ph
72	25.1909	SW Velorum	8 40 21	—47 2.5	8.8	9.8	ph
73	26.1909	SX Velorum	8 41 32	—45 58.7	8.5	9.3	ph
74	32.1913	T Pyxidis	9 0 32	—31 58.7	7.4	14.1	ph
75	33.1913	SY Velorum	9 8 44	—43 22.0	8.5	9.5	ph
76	36.1913	ST Hydrae	9 33 14	—20 12.1	9.4	<12.0	ph
77	37.1913	SZ Velorum	9 46 12	—44 11.1	9.5	10.7	ph
78	38.1913	W Antliae	9 46 42	—29 25.6	9.2	10.2	ph
79	39.1913	SU Hydrae	9 49 4	—21 22.6	9.4	10.4	ph
80	40.1913	X Antliae	10 2 14	—29 35.1	9.3	<12.0	ph
81	41.1913	Y Antliae	10 4 9	—34 41.3	9.1	9.9	ph
82	43.1913	TT Velorum	10 16 9	—45 44.0	10.2	<12.0	ph
83	44.1913	V Antliae	10 16 41	—34 17.7	7.7	<12.0	ph
84	56.1906	AA Carinae	10 18 26	—60 38.6	13.5	14.5	ph
85	60.1906	AD Carinae	10 31 38	—58 35.1	12.0	13.3	ph
86	45.1913	Z Antliae	10 41 22	—34 43.5	9.6	10.6	ph
87	76.1906	AE Carinae	10 56 44	—58 15.5	14.0	15.0	ph
88	63.1911	T Crateris	11 18 53	—19 21.8	9.2	10.2	ph
89	171.1906	VY Centauri	11 26 31	—50 53.2	9.2	10.2	ph
90	175.1906	RT Muscae	11 39 51	—66 45.0	8.7	9.7	ph
91	46.1913	VZ Centauri	11 47 32	—60 58.1	8.3	8.7	ph
92	128.1906	RV Crucis	12 12 18	—61 12.3	13.1	14.2	ph
93	38.1910	VV Draconis	12 12 46	+69 48.6	10.31	10.82	ph
94	133.1910	RR Can. Ven.	12 24 11	+35 13	10	11	ph
95	133.1906	RW Crucis	12 34 17	—60 52.2	15.0	16.0	ph
96	136.1906	RX Crucis	12 43 36	—61 13.5	15.0	16.0	ph
97	138.1906	RY Crucis	12 48 22	—63 23.4	12.7	13.8	ph
98	139.1906	RZ Crucis	12 51 15	—62 56.5	14.0	15.3	ph
99	14.1913	T Comae Ber.	12 53 42	+23 40	10½	<13	ph
100	68.1905	SZ Virginis	12 57 23	+ 5 43.3	10.3	11.5	ph
101	144.1906	RU Muscae	12 57 23	—64 15.1	13.4	14.6	ph
102	187.1906	WW Centauri	13 3 11	—59 42.9	9.4	10.5	ph
103	148.1906	WX Centauri	13 6 26	—62 52.0	11.5	12.5	ph
104	150.1906	WY Centauri	13 9 47	—62 30.7	12.3	13.5	ph
105	151.1906	WZ Centauri	13 13 2	—62 24.1	12.9	14.2	ph
106	56.1901	S Chamaeleontis	13 24 36	—77 2.9	7.0	8.0	ph
107	189.1906	XX Centauri	13 33 46	—57 6.3	7.6	8.7	ph
108	94.1907	T Circini	13 36 15	—64 58.2	10.0	11.0	ph
109	52.1910	XY Centauri	13 42 40	—44 1.0	9.4	10.4	ph
110	8.1906	TT Virginis	13 50 20	—10 43.8	14.0	15.0	ph
111	9.1906	TU Virginis	13 51 32	—12 4.3	13.0	14.0	ph
112	10.1906	TV Virginis	13 58 49	— 9 31.2	13.0	14.0	ph
113	57.1901	RS Lupi	14 16 57	—47 4.0	10.7	11.7	ph
114	99.1907	RT Lupi	14 24 7	—48 14.6	10.5	11.5	ph
115	106.1907	V Apodis	14 54 59	—71 12.7	10.5	11.5	ph

Designation of Recently Discovered Variable Stars—Continued.

No.	Prov. Des. A. N.	Name	Position 1900 R. A. h m s	Decl. ° ′	Magnitude Max. m	Min. m	
116	107.1907	RR Normae	15 5 4	−54 56.1	9.5	10.5	ph
117	16.1913	SU Librae	15 16 1	−15 32.3	14½	16¼	ph
118	216.1907	SV Librae	15 27 21	−26 50.8	10.2	<11.5	ph
119	112.1907	RS Normae	15 57 24	−53 38.5	10.0	11.0	ph
120	193.1904	AM Scorpii	16 1 10	−23 24.0	12.9	14.0	ph
121	201.1904	AN Scorpii	16 6 7	−19 40.3	13.0	14.2	ph
122	204.1904	AO Scorpii	16 9 8	−21 30.6	11.1	12.1	ph
123	207.1904	AP Scorpii	16 10 10	−23 21.3	12.3	13.7	ph
124	213.1904	AQ Scorpii	16 14 36	−23 0.2	12.9	14.1	ph
125	216.1904	AR Scorpii	16 15 48	−22 39.1	13.6	14.7	ph
126	112.1910	RT Normae	16 15 49	−59 6.8	10.0	11.0	ph
127	217.1904	AS Scorpii	16 16 42	−20 44.3	13.3	14.7	ph
128	226.1904	TZ Ophiuchi	16 23 13	−20 1.0	12.4	13.5	ph
129	113.1910	RT Triang. austr.	16 25 19	−62 55.4	9.1	10.1	ph
130	227.1904	AT Scorpii	16 25 28	−27 41.7	12.2	<13.6	ph
131	231.1904	AU Scorpii	16 28 2	−26 24.2	11.7	13.1	ph
132	235.1904	AV Scorpii	16 31 12	−27 53.6	13.7	<15.0	ph
133	236.1904	AW Scorpii	16 31 32	−29 6.9	13.2	14.2	ph
134	12.1913	W Ursae Min.	16 34 50	+86 25.9	8.4	9.3	ph
135	58.1910	AX Scorpii	16 35 39	−26 54.7	8.8	9.8	ph
136	241.1904	AY Scorpii	16 38 16	−27 49.9	13.1	14.1	ph
137	244.1904	AZ Scorpii	16 39 1	−26 41.5	12.6	13.8	ph
138	246.1904	BB Scorpii	16 39 43	−29 31.9	13.6	14.9	ph
139	248.1904	BC Scorpii	16 40 25	−29 57.5	13.8	<14.8	ph
140	249.1904	BD Scorpii	16 40 29	−27 56.8	13.6	<14.8	ph
141	250.1904	BE Scorpii	16 41 6	−30 15.7	12.5	13.5	ph
142	253.1904	BF Scorpii	16 42 12	−29 56.9	12.8	13.8	ph
143	255.1904	BG Scorpii	16 43 36	−27 16.2	13.7	14.9	ph
144	258.1904	BH Scorpii	16 44 4	−27 49.6	13.0	14.0	ph
145	261.1904	BI Scorpii	16 44 38	−27 47.6	13.8	14.8	ph
146	222.1907	UU Ophiuchi	16 51 14	−25 38.6	10.2	<11.6	ph
147	265.1904	AS Sagittarii	17 49 6	−21 43.5	12.6	13.9	ph
148	268.1904	AT Sagittarii	17 57 16	−26 28.6	11.0	12.3	ph
149	269.1904	AU Sagittarii	17 58 24	−22 57.5	13.4	14.5	ph
150	270.1904	AV Sagittarii	17 58 45	−22 44.1	10.9	12.0	ph
151	273.1904	AW Sagittarii	18 2 24	−23 4.8	14.0	15.1	ph
152	25.1908	AX Sagittarii	18 2 34	−18 33.9	8.0	9.0	ph
153	31.1908	RS Serpentis	18 11 40	−13 6.1	10.1	10.7	ph
154	18.1913	TX Lyrae	18 13 12	+40 39.2	10.2	<13.0	ph
155	277.1904	AY Sagittarii	18 17 26	−18 37.4	10.4	11.4	ph
156	278.1904	AZ Sagittarii	18 17 46	−30 38.8	10.6	12.0	ph
157	128.1910	RT Pavonis	18 25 21	−69 57.6	8.7	9.8	ph
158	61.1908	SY Scuti	18 45 2	−10 50.1	14.0	15.0	ph
159	40.1908	BB Sagittarii	18 45 3	−20 24.6	7.6	8.6	ph
160	66.1908	SZ Scuti	18 48 15	−12 38.5	15.0	<16.0	ph
161	69.1908	TT Scuti	18 49 15	−12 18.8	14.4	15.4	ph
162	98.1908	TU Scuti	18 52 7	−13 2.8	14.2	15.5	ph
163	71.1908	TV Scuti	18 52 26	−12 35.4	14.7	<16.0	ph
164	72.1908	TW Scuti	18 53 20	−15 8.7	14.0	15.2	ph
165	74.1908	BC Sagittarii	18 53 57	−12 6.8	14.5	<15.8	ph
166	75.1908	UX Aquilae	18 54 52	−11 37.7	14.8	15.8	ph
167	76.1908	UY Aquilae	18 55 30	−11 3.5	13.5	14.5	ph
168	79.1908	BD Sagittarii	18 57 33	−12 16.0	14.4	<15.8	ph
169	106.1908	BE Sagittarii	18 59 5	−15 9.0	13.0	14.3	ph
170	107.1908	BF Sagittarii	18 59 21	−12 8.1	14.8	<15.8	ph
171	131.1010	RX Telescopii	18 59 38	−46 7.3	8.9	9.9	ph
172	25.1907	RY Vulpeculae	19 0 26	+24 37.3	13.0	14.3	ph
173	109.1908	BG Sagittarii	19 3 54	−14 37.6	14.8	15.8	ph
174	22.1913	TY Lyrae	19 5 54	+27 53.8	9.4	<13.0	ph
175	88.1908	UZ Aquilae	19 7 58	−10 35.2	14.5	<15.5	ph

Designation of Recently Discovered Variable Stars.—Continued.

No.	Prov. Des. A. N.	Name	Position 1900 R. A.	Position 1900 Decl.	Magnitude Max.	Magnitude Min.	
			h m s	° ′	m	m	
176	282.1904	BH Sagittarii	19 8 35	−18 59.6	12.7	13.7	ph
177	—	BI Sagittarii	19 44 45	−16 14.8	9.8	13.0	ph
178	75.1911	BC Cygni	20 17 56	+37 13.2	11.5	12.5	ph
179	15.1906	BD Cygni	20 43 30	+31 21.8	13.8	14.9	ph
180	25.1906	BE Cygni	20 59 17	+32 40.0	12.5	13.7	ph
181	—	SX Cephei	21 0 24	+67 48.0	14½	16¼	ph
182	47.1913	Y Microscopii	21 0 54	−34 40.3	9.6	10.6	ph
183	48.1913	Z Microscopii	21 10 21	−30 42.1	11.0	11.8	ph
184	196.1907	RS Indi	21 27 55	−70 46.7	9.0	10.0	ph
185	26.1906	UZ Pegasi	21 45 8	+29 40.0	13.0	14.4	ph
186	49.1913	V Gruis	21 45 40	−42 50.4	9.5	10.0	ph
187	51.1913	W Piscis austr.	22 2 8	−33 19.9	10.0	<11.5	ph
188	5.1910	VV Pegasi	22 8 16	+17 55	10.4	11.2	ph
189	9.1913	SY Cephei	22 10 18	+62 1.7	10.3	11.6	v
190	54.1913	W Gruis	22 35 26	−44 21.7	9.5	10.0	ph
191	55.1913	SZ Aquarii	22 37 26	−21 42.0	9.2	<11.0	ph
192	28.1913	ST Lacertae	22 38 53	+42 59.2	10.3	<13.4	ph
193	137.1908	TT Aquarii	22 49 41	− 9 54.4	10.5	11.5	ph
194	26.1913	UV Cassiopeiae	22 58 6	+59 6.3	12	15.6	v
195	79.1901	RT Andromedae	23 6 42	+52 29.0	9.0	9.5	v

COMET AND ASTEROID NOTES.

Delavan's Comet 1913 *f*.—Delavan's comet is now out far enough from the sun to be observed in the morning, and is still a bright telescopic object. The declination is so far south that observers in the northern hemisphere must observe the comet under unfavorable conditions, but in the southern hemisphere the conditions are good. The following ephemeris, taken from the *Astronomische Nachrichten* No. 4776, was computed by Mr. G. Van Biesbroeck of the Royal Observatory at Uccle, near Brussels, Belgium.

EPHEMERIS OF DELAVAN'S COMET 1913 *f*.

(For Berlin Midnight. From *Astronomische Nachrichten* No. 4776).

	True α	True δ	log *r*	log Δ	Br.
	h m s	° ′			m
Jan. 30	17 23 22	−20 31.7	0.26758	0.37082	6.4
31	24 29	20 50.5			
Feb. 1	25 35	21 9.1			
2	26 40	21 27.8			
3	27 44	21 46.4	0.27813	0.37029	6.4
4	28 47	22 5.0			
5	29 49	22 23.5			
6	30 51	22 42.0			
7	31 51	23 0.5	0.28849	0.36930	6.5
8	32 50	23 19.0			
9	33 48	23 37.5			
10	34 45	23 56.0			
11	35 41	24 14.5	0.29864	0.36788	6.5
12	36 36	24 33.0			
13	37 30	24 51.4			
14	38 23	25 9.9			
15	39 14	25 28.5	0.30859	0.36606	6.6
16	40 5	25 47.0			
17	17 40 54	−26 5.5			

EPHEMERIS OF DELAVAN'S COMET 1913 *f* —Continued.

	True α	True δ	log r	log Δ	Br.
	h m s	° ′			m
Feb. 18	17 41 42	−26 24.1			
19	42 29	26 42.7	0.31833	0.36388	6.6
20	43 14	27 1.4			
21	43 59	27 20.0			
22	44 41	27 38.8			
23	45 23	27 57.5	0.32788	0.36137	6.6
24	46 3	28 16.4			
25	46 42	28 35.2			
26	47 20	28 54.1			
27	47 56	29 13.1	0.33722	0.35858	6.7
28	48 31	29 32.1			
Mar. 1	49 4	29 51.2			
2	49 36	30 10.4			
3	50 6	30 29.6	0.34638	0.35555	6.7
4	50 35	30 48.9			
5	51 2	31 8.3			
6	51 27	31 27.8			
7	51 51	31 47.3	0.35534	0.35233	6.7
8	52 13	32 6.9			
9	52 34	32 26.5			
10	52 52	32 46.3			
11	53 9	33 6.1	0.36412	0.34897	6.8
12	53 24	33 26.0			
13	53 37	33 46.0			
14	53 49	34 6.1			
15	17 53 58	−34 26.3	0.37271	0.34553	6.8

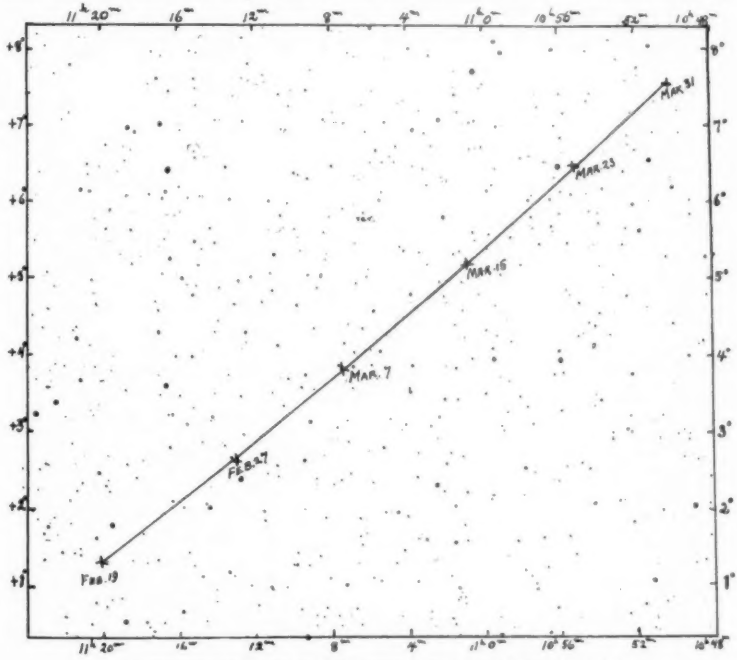
Numbering of Recently Discovered Asteroids.—In the *Astronomische Nachrichten* Nos. 4739 and 4772 the number of minor planets whose orbits have been determined is brought up from 754 to 791. The elements of all of those numbered from 755 to 791, together with eight others for which the elements are not sufficiently certain to warrant assigning them permanent numbers, are given in *A.N.* 4772.

The numbers, provisional designation, name of discoverer, place and date of discovery are given in the following table:

No.	Prov.Des.	Discoverer	Place	Date
755	1908 CZ	Metcalf	Taunton, Mass.	1908 Apr. 6
756	1908 DC	Metcalf	Taunton	1908 Apr. 26
757	1908 EJ	Metcalf	Taunton	1908 Sept. 30
758	1912 PE	H. E. Wood	Johannesburg	1912 May 18
759	1913 SJ	Kaiser	Heidelberg	1913 Aug. 26
760	1913 SL	Neujmin	Simeis	1913 Aug. 28
		Kaiser	Heidelberg	
761	1913 SO	Kaiser	Heidelberg	1913 Sept. 8
762	1913 SQ	Neujmin	Simeis	1913 Sept. 3
763	1913 ST	Kaiser	Heidelberg	1913 Sept. 25
764	1913 SU	Kaiser	Heidelberg	1913 Sept. 26
765	1913 SV	Kaiser	Heidelberg	1913 Sept. 26
766	1913 SW	Kaiser	Heidelberg	1913 Sept. 29
767	1913 SX	Metcalf	Taunton	1913 Sept. 23
		Neujmin	Simeis	1913 Sept. 28
768	1913 SZ	Neujmin	Simeis	1913 Oct. 4
769	1913 TA	Neujmin	Simeis	1913 Oct. 6
770	1913 TE	Massinger	Heidelberg	1913 Oct. 31
771	1913 TO	Rheden	Wien	1913 Nov. 21
772	1913 TR	Massinger	Heidelberg	1913 Dec. 19
773	1913 TV	Kaiser	Heidelberg	1913 Dec. 22
774	1913 TW	LeMorvan	Paris	1913 Dec. 19

No.	Prov.Des.	Discoverer	Place	Date
775	1914 TX	Lagrula	Nice	1914 Jan. 6
776	1914 TY	Massinger	Heidelberg	1914 Jan. 24
777	1914 TZ	Kaiser	Heidelberg	1914 Jan. 24
778	1914 UA	Kaiser	Heidelberg	1914 Jan. 25
779	1914 UB	Neujmin	Simeis	1914 Jan. 25
780	1914 UC	Neujmin	Simeis	1914 Jan. 25
781	1914 UF	Neujmin	Simeis	1914 Jan. 25
782	1914 UK	Palisa	Wien	1914 Mar. 18
783	1914 UL	Palisa	Wien	1914 Mar. 18
		Lagrula	Nice	1914 Mar. 21
784	1914 UM	Metcalf	Winchester, Mass.	1914 Mar. 20
		Kaiser	Heidelberg	1914 Mar. 29
785	1914 UN	Massinger	Heidelberg	1914 Mar. 30
786	1914 UO	Kaiser	Heidelberg	1914 Apr. 20
787	1914 UQ	Neujmin	Simeis	1914 Apr. 20
788	1914 UR	Kaiser	Heidelberg	1914 Apr. 28
789	1914 UU	Neujmin	Simeis	1914 June 24
790	1912 NW	Wood	Johannesburg	1912 Jan. 16
791	1914 UV	Neujmin	Simeis	1914 June 29

The Apparent Path of the Asteroid (3) Juno.—The little planet Juno, the third of the asteroids to be discovered, will be of magnitude 8.8 at the time of its opposition in March and it may be that some of our readers will enjoy



APPROXIMATE PATH OF JUNO FROM FEB. 19 TO MAR. 31 1915.

following it from night to night. The accompanying chart shows the approximate course of the asteroid among the stars. The region shown on the chart is in the

constellation Leo, from 5° to 12° west of the star β Virginis. The brightness of the stars shown ranges from magnitude 5 to magnitude 9.5 and the asteroid will be about as bright as the stars represented by the next to the smallest black dots. The ephemeris from which the plotted positions of Juno were taken is published in the Berliner Jahrbuch for 1917. The predicted places may be in error by as much as 1° or more in any direction, so that the observer will have to search over quite a wide circle around the place indicated for a particular night, but when the planet is once found and the error of the predicted position determined it will be easy to draw a new curve across the chart, from which its position on future nights may be taken off accurately.

EPHEMERIS OF (3) JUNO

	α	δ	log r	log Δ
	h m	° ′		
Feb. 19	11 20.2	+1 26	0.430	
27	11 14.1	+2 42		0.239
Mar. 7	11 07.6	+4 01		0.241
15	11 01.2	+5 19		0.248
23	10 55.4	+6 33		0.260
31	10 50.7	+7 37	0.446	

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Dec. 1914-Jan. 1915.

The cold and inclement weather of the past month has interfered materially with the observations of variables, and results in a comparatively meagre monthly report.

Mr. Richter again leads in the number of observations individually contributed this month, his list contained 231 observations.

Thanks are due Messrs. Lindsley and Pickering for many blue prints for distribution. It is a pleasure to state that Dr. Gray is improving in health. We wish him a speedy convalescence.

Mr. Herriot, of Pittsburg, writes that he is engaged in some microphotometric work on variables, using the 4″ doublet attached to the 13″ refractor of the Allegheny Observatory. It will be interesting to compare the results he obtains, with our visual estimates, where possible.

On December 11 a maximum of about 9.3 magnitude of the variable 074922 U Geminorum was observed by several members. This variable should be kept under close observations.

The variable 213843 SS Cygni recently established a long maximum, rising on the 25th of December. Mr. Jacobs' estimate of 7.9 magnitude on the 27th was the brightest, he writes, that he has ever seen the variable.

On the the evening of December 17 the Secretary, when observing the variable 044617 V Tauri, noted an uncharted seventh magnitude star. This proved to be the asteroid Vesta. In all such cases notice of such an observation should be sent to the Harvard College Observatory, as there is always the possibility of the discovery of a Nova. An observation of this character is further evidence of the interesting features that enter into the observational work that claims our attention.

VARIABLE STAR OBSERVATIONS Dec. 1914-Jan. 1915.

001032
S Sculptoris

Mo.	Day	Est	Obs.
12	6	9.0	R
	7	9.0	R
	9	8.9	R
	10	8.8	R
	12	8.7	R
	13	8.2	R
	14	8.2	R

001726
T Androm.

12	2	10.9	Bb
	4	10.8	Bb
	4	10.6	Bu
	12	10.3	Bg
	12	10.3	S
	15	9.9	V
1	7	9.5	O

001755
T Cassiop.

12	2	8.4	Bb
	4	8.3	Bb
	4	8.3	Bu
	6	8.5	R
	7	8.3	R
	9	8.8	R
	10	8.7	R
	12	9.2	S
	12	8.9	R
	13	9.1	R
	14	9.1	R

001838
R Androm.

12	12	11.9	Hu

001909
S Ceti

12	4	8.8	Bu
	12	8.9	S
	16	8.7	Hu
	21	8.4	Bg

003179
Y Cephei

12	18	10.2	Hu

004047
U Cassiop.

12	6	11.6	L
	11	11.3	L

004435
V Androm.

12	2	11.3	Bb
	4	11.2	Bb

004533
RR Androm.

12	4	9.4	Bu
	10	9.4	O
	16	9.4	O
1	7	10.0	O

004746
RV Cassiop.

11	26	10.8	L
12	2	9.2	Bb
	4	9.1	Bb

004958
W Cassiop.

12	11	11.4	Sp
	16	11.8	M

011272
S Cassiop.

12	2	11.8	Ly
	2	11.7	Bb
	4	11.6	Bb
	16	11.8	M
	18	11.1	Bg

011208
S Piscium

12	10	10.0	O
	13	10.5	R
	15	10.2	O
	17	10.1	B

012502
R Piscium

12	10	8.0	O
	12	8.7	S
	13	8.8	R
	14	8.9	R
	15	8.4	O
	16	8.6	Pi

013238
RU Androm.

12	13	11.5	R
	14	11.5	R

014958
X Cassiop.

11	28	10.7	L
12	2	9.4	Bb
	4	9.4	Bb

015354
U Persei

12	2	8.0	Bb
	2	8.4	Ly
	4	8.0	Bu
	4	8.0	Bb
	13	8.6	Hy
	15	8.4	V

021024
R Arietis

12	2	11.3	Bb
	4	11.4	Bb

021143
W Androm.

12	2	11.0	Bb
	10	11.3	Y

021403
o Ceti

Mo.	Day	Est	Obs.
12	2	8.6	Ly
	6	8.2	L
	6	8.6	R
	7	8.5	R
	9	8.5	R
	10	8.3	R
	10	7.7	O
	12	7.8	Bu
	12	8.3	R
	12	7.3	O
	13	8.1	R
	13	8.5	Hy
	14	7.1	E
	14	7.9	R
	15	6.6	L
	15	6.8	O
	16	6.6	Hu
	16	6.7	Pi
	17	6.7	O
	18	6.8	O
	18	7.2	Bg
	19	5.9	L
	20	6.6	O
	21	6.4	O
	22	6.4	O
1	3	4.6	O
	4	4.6	O
	5	4.5	O
	7	4.4	O
	9	4.3	O

021658
S Persei

12	2	11.0	Ly
	2	10.7	Bb
	11	11.4	Sp
	12	10.4	Bu
	16	11.3	Sp

022150
RR Persei

12	10	12.5	Y

022813
U Ceti

12	2	11.1	Bb
	16	11.0	Pi
	17	10.2	B
	21	10.2	Bg
1	5	9.1	O
	9	9.1	O

023133
R Triang.

12	2	9.0	Bg
	10	9.5	O
	12	9.5	Bu
	12	9.6	O
	15	9.7	O
	17	9.8	O
	20	9.7	O
	22	9.8	O

024356
W Persei

Mo.	Day	Est	Obs.
11	26	10.2	L
12	2	10.3	Ly
	6	10.6	R
	7	10.6	R
	7	9.2	Hy
	9	10.6	R
	11	10.4	O
	12	10.4	Pi
	12	10.4	R
	12	9.4	Hu
	13	9.4	Hy
	15	10.4	L
	16	10.0	M
	18	11.3	Hy
	25	11.3	Hy

031401
X Ceti

12	16	9.2	Pi

032043
Y Persei

12	2	8.8	Bb
	3	8.6	Ly
	6	9.4	R
	7	9.5	R
	7	8.3	Hy
	9	9.7	R
	10	9.6	R
	11	9.0	O
	12	8.6	M
	12	8.4	Bu
	12	9.5	R
	13	8.2	Hy
	13	9.6	R
	14	9.5	R
	16	8.6	Ma
	17	8.5	Hu
	25	8.0	Hy

033362
U Camelop.

12	1	8.6	Bu
	6	8.6	R
	7	8.5	R
	9	8.6	R
	10	8.6	R
	12	8.4	R
	13	8.6	R
	14	8.6	R

035915
V Eridani

12	2	9.6	Bb
	16	8.8	Pi

042209
R Tauri

12	12	13.0	B
	16	11.6	Hu
	17	11.6	Hu

042215
W Tauri

Mo.	Day	Est	Obs.
12	2	11.0	Bb
	3	10.3	B
	4	11.0	Ly
	12	11.2	Bu
	12	10.8	O
	13	10.9	Bg
	14	11.2	M
	22	11.8	B

042309
S Tauri

12	16	11.0	Hu
	17	11.0	Hu

043208
RX Tauri

12	2	11.6	Bb
	12	10.6	B
	12	11.0	O
	16	11.0	M
	17	10.0	Hu
	22	10.3	B
1	3	9.7	O
	5	9.8	O
	7	9.3	O
	9	9.1	O

043274
X Camelop.

12	3	12.0	B
	11	11.3	O
	15	11.1	L
	15	11.1	O
	16	10.6	Sp
	17	10.9	O
	23	10.3	O
1	3	8.6	O
	4	8.3	O
	5	8.4	O
	7	8.0	O
	9	8.0	O

044617
V Tauri

12	10	11.7	B
	16	10.9	O
	17	10.9	O
	21	10.5	O
	22	10.0	B
1	3	9.7	O
	5	10.2	O
	7	10.2	O

045514
R Leporis

11	28	8.2	L
12	1	8.2	Bu
	15	8.6	L
	16	8.0	B

VARIABLE STAR OBSERVATIONS Dec. 1914-Jan.1915—Continued.

050022
T Leporis

Mo.	Day	Est	Obs.
12	13	8.5	R
	14	8.4	R

050953
R Aurigae

Mo.	Day	Est	Obs.
12	2	10.1	Bb
	4	9.8	Bu
	4	10.3	Ly
	6	9.7	R
	7	9.6	R
	9	9.7	R
	10	9.5	R
	12	9.6	Bu
	12	9.4	R
	13	9.5	R
	14	9.4	R
	15	9.1	B
	15	9.6	M

052034
S Aurigæ

Mo.	Day	Est	Obs.
11	26	9.1	L
12	14	10.3	M
	15	9.6	L

052036
W Aurigae

Mo.	Day	Est	Obs.
12	2	9.8	Bb
	12	10.3	R
	12	10.5	O
	13	10.3	R
	14	10.3	R
	14	10.6	M
	15	10.1	B

052404
S Orionis

Mo.	Day	Est	Obs.
12	12	10.2	Bu
	16	9.9	B

053000
T Orionis

Mo.	Day	Est	Obs.
12	12	9.8	Pi
	14	10.4	M
	22	10.5	M
	25	10.5	M
	27	9.8	Pi

054920
U Orionis

Mo.	Day	Est	Obs.
11	26	10.3	L
12	1	10.8	Bu
	2	10.7	Bb
	15	11.4	L
	16	11.0	M
	16	11.0	Hu

054974
V Camelop.

Mo.	Day	Est.	Obs.
12	1.2	13.1	B

055353
Z Aurigae

Mo.	Day	Est.	Obs.
12	10	10.4	Y

060450
X Aurigae

Mo.	Day	Est.	Obs.
11	28	12.1	L
12	2	12.6	Bb
	15	10.1	L
	15	9.8	B
	16	9.6	V

060547
SS Aurigae

Mo.	Day	Est.	Obs.
11	26.2	10.6	E
	28.6	12.0	L
12	2	11.1	Bb
	15	11.9	M
	15	13.6	B

061647
V Aurigae

Mo.	Day	Est.	Obs.
12	12	9.5	Bu
	15	8.9	B

063159
U Lyncis

Mo.	Day	Est.	Obs.
12	15	11.8	M

064030
X Gemin.

Mo.	Day	Est.	Obs.
12	16	9.9	V
	26	10.2	L
1	5	9.0	O
	9	9.1	O

064922
Nova Gemin. 2

Mo.	Day	Est.	Obs.
11	28	11.7	L
12	2	12.0	Bb

065208
X Monoc.

Mo.	Day	Est.	Obs.
11	28	8.9	L

065353
R Lyncis

Mo.	Day	Est.	Obs.
12	17	10.7	B
	18	11.0	O
1	9	9.9	O

070122a
R Gemin.

Mo.	Day	Est.	Obs.
12	2	8.6	Bb
	12	8.8	Pi
	12	9.1	R
	13	8.9	R
	14	9.0	R
	15	9.2	Bu
	16	8.7	Sp
	17	9.0	B
	17	8.9	Hu
1	9	9.8	O

070312
R Can. Min.

Mo.	Day	Est.	Obs.
11	26	9.3	L
12	25	9.3	M
1	7	9.5	O

072708
S Can. Min.

Mo.	Day	Est.	Obs.
11	26	8.6	L
12	2	8.4	Bb
	5	8.4	Ly
	12	8.0	Bu
	13	8.2	Bg
	14	8.1	M
	25	7.7	M
	27	7.8	Pi
1	7	7.3	O

073508
U Can. Min.

Mo.	Day	Est.	Obs.
11	26	9.7	L
12	12	8.8	Bu
1	7	9.5	O

074323
T Gemin.

Mo.	Day	Est.	Obs.
12	2	8.7	Bb
	12	8.9	Pi
	15	8.1	Bu
	18	9.0	Bg
1	7	9.1	O
	9	9.1	O

074922
U Gemin.

Mo.	Day	Est.	Obs.
12	12.5	9.6	O
	12.6	9.4	Pi
	13.2	9.9	B
	14.6	8.9	M
	14.6	9.8	O
	15.5	10.7	O
	15.6	10.0	L
	16.5	10.5	B
	16.5	11.0	Pi
	16.6	10.9	Bb
	17.5	12.3	Hu
	17.5	11.1	B
	25.6	9.5	M

081112
R Cancri

Mo.	Day	Est.	Obs.
11	28	11.4	L

082405
RT Hydrae

Mo.	Day	Est.	Obs.
11	28	7.4	L

085120
T Cancri

Mo.	Day	Est.	Obs.
11	28	10.1	L

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
12	12	8.8	S
	26	7.7	E

094211
R Leonis

Mo.	Day	Est.	Obs.
11	28	6.3	L
12	11	6.2	Sp
	13	6.6	Bg
	15	6.0	L
	26	6.4	E

103212
U Hydrae

Mo.	Day	Est.	Obs.
11	26	5.0	L
	28	5.0	L
12	15	5.1	L

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
12	11	11.8	Sp
	13	11.7	Bg
	16	11.9	Sp
	17	11.2	B

104620
V Hydrae

Mo.	Day	Est.	Obs.
11	28	6.0	L

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
12	2	8.5	Ly
	4	8.6	Bu
	11	7.9	Sp
	12	8.0	S
	12	8.4	Bu
	13	7.8	Bg
	15	8.3	Bu
	16	7.8	Sp
	17	8.0	M
	24	7.3	E
	25	7.8	M

123307
R Virginis

Mo.	Day	Est.	Obs.
12	15	8.7	L

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
12	2	8.5	Ly
	4	8.8	Bu
	11	8.5	Sp
	12	9.2	Bu
	12	9.0	S
	13	9.2	Bg
	15	8.7	L
	16	8.8	Sp
	17	9.0	M
	24	9.0	E
	25	9.2	M

132422
R Hydrae

Mo.	Day	Est.	Obs.
12	15	8.7	L

132706
S Virginis

Mo.	Day	Est.	Obs.
11	28	7.0	L

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
12	15	9.6	L
	17	9.9	M
	26	9.7	E
	28	9.4	M

141567
U Urs. Min.

Mo.	Day	Est.	Obs.
12	12	9.4	S
	17	9.2	B
1	4	8.8	S

141954
S Boötis

Mo.	Day	Est.	Obs.
12	15	8.4	L
	26	8.8	E

142539
V Boötis

Mo.	Day	Est.	Obs.
12	15	9.4	L
	28	8.0	M

142584
R Camelop.

Mo.	Day	Est.	Obs.
11	26	8.2	L
12	10	8.3	O
	16	8.4	O
	17	8.1	B
	21	8.4	O
1	3	8.8	O
	7	8.7	O

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
11	28	10.6	L
12	5	10.4	Ly
	14	10.8	Bg
	15	11.1	L

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
11	26	6.1	L
12	15	6.0	L
	26	5.9	E

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
12	6	9.5	R
	7	9.4	R
	9	9.5	R
	10	9.4	R
	12	9.4	Bu
	12	9.4	R
	13	9.4	R
	14	9.2	Bg

163266
R Draconis

Mo.	Day	Est.	Obs.
12	4	7.4	E
	4	7.4	Bu
	5	7.5	Ly
	6	7.2	R
	7	7.1	R
	9	7.1	R

VARIABLE STAR OBSERVATIONS Dec. 1914-Jan. 1915—Continued.

R Draconis

Mo.	Day	Est.	Obs.
12	10	7.2	R
	11	7.3	O
	12	7.8	Bu
	12	7.0	R
	12	7.3	S
	13	7.0	R
	14	7.1	R
1	4	7.6	S

164055

S Draconis

12	28	8.8	M

165631

RV Herculis

12	28	10.3	M

175519

RY Herculis

12	4	10.7	E

181136

W Lyrae

12	6	8.3	R
	7	8.8	Hy
	9	8.3	R
	9	8.7	Hy
	12	8.9	Bg
	13	8.3	Hy
	13	8.2	R
	14	8.2	R
	21	8.7	E

183308

X Ophiuchi

11	29	6.8	L

184205

R Scuti

11	26	5.2	L
	27	5.2	L
	29	5.3	L
12	6	5.3	L
	6.6	5.7	L
	11	5.4	L
	15	5.6	L

184633

β Lyrae

12	6.6	3.7	R
	7.7	3.8	R
	8.6	3.7	R
	9.6	3.8	R
	10.6	3.7	R
	12.6	3.8	R
	13.6	3.9	R
	14.6	3.9	R

185243

R Lyrae

12	6.6	4.6	R
	7.6	4.8	R
	9.6	4.7	R
	10.6	4.6	R
	12.6	4.7	R
	13.6	4.5	R
	14.6	4.6	R

190108

R Aquilae

Mo.	Day	Est.	Obs.
11	26	6.3	L
12	6	6.6	L
	15	6.8	B

191350

TZ Cygni

12	6	10.6	L

190926

X Lyrae

12	2	9.1	Ly
	6	9.2	R
	7	9.3	R
	9	9.2	R
	12	9.3	R
	12	8.6	Bg
	13	8.4	Hy
	13	9.2	R
	14	9.2	R
	25	9.6	E

191637

U Lyrae

12	25	11.5	E

193449

R Cygni

12	4	12.4	Bb
	16	11.0	B

193732

TT Cygni

12	2	8.2	L
	4	8.0	Bb
	6	8.3	L
	6	8.4	R
	7	8.0	Hy
	7	8.4	R
	9	8.4	R
	10	8.4	R
	12	8.6	M
	12	8.5	R
	22	8.0	Bg
	12	8.0	Hu
	13	7.4	Hy
	13	8.6	R
	14	8.6	R
	15	8.6	Bu
	16	8.3	Ly
	25	7.4	Hy
	25	8.2	E

194048

RT Cygni

11	26	9.3	L
12	2	9.3	Ly
	4	9.4	Bb
	6	9.3	R
	6	9.7	L
	7	9.3	R
	9	9.4	R
	10	9.7	O
	10	9.3	R

RT Cygni

12	9.3	R	
	9.2	Hu	
	9.6	Bg	
	9.9	S	
	9.6	M	
	9.3	R	
	9.3	R	
	10.6	Bu	
	9.0	B	
	9.8	Ly	
	9.7	O	
	10.8	E	

194348

TU Cygni

12	4	12.6	Bb
	12	12.1	Hu

194632

χ Cygni

11	27	4.8	L
	28	4.9	Hy
12	2	5.3	Ly
	4	5.2	Bu
	4	5.3	E
	4	5.3	Bb
	6	5.2	R
	7	5.5	R
	7	4.8	Hy
	8	4.8	Hy
	9	5.0	R
	9	4.8	Hy
	10	5.1	O
	11	5.1	O
	12	5.2	Ly
	12	4.9	Bu
	12	4.9	R
	12	5.1	O
	12	5.0	Hu
	12	5.0	M
	13	4.9	Hy
	13	4.8	R
	13	5.0	Bg
	14	5.1	O
	14	4.8	R
	15	5.1	O
	16	5.1	O
	16	5.2	Ly
	17	5.1	O
	18	5.2	O
	20	5.2	O
	21	5.1	O
	22	5.2	O
	25	5.2	E
	25	5.2	Hy
	26	5.5	Ma
	27	5.2	Hy
1	3	5.2	O
	4	5.4	O
	5	5.4	O

194700

η Aquilae

12	6.6	4.6	R
	7.6	4.2	R
	9.6	4.3	R
	10.6	4.4	R
	12.6	4.5	R
	13.6	4.7	R
	14.6	4.2	R

195116

S Sagittae

12	4.4	6.0	Bu
	6.6	5.6	Mu
	6.6	5.9	R
	7.6	5.5	R
	9.6	5.7	R
	10.4	5.5	O
	10.5	5.5	Mu
	10.6	5.8	R
	11.4	5.5	O
	12.4	5.9	Bu
	12.4	5.8	O
	12.6	6.3	R
	13.6	5.9	Mu
	13.6	6.1	R
	14.4	5.8	O
	14.5	6.0	Mu
	14.6	6.2	R
	15.4	5.4	O
	15.4	5.6	Bu
	15.4	5.4	O
	17.4	5.4	O
	18.4	5.5	O
	18.5	5.5	Mu
	20.4	5.7	O
	20.5	5.6	Ma
	21.5	5.8	Mu
	22.5	6.0	Mu

195849

Z Cygni

12	14	12.7	Y
	16	12.4	B

200357

S Cygni

12	12	13.2	B

200647

SV Cygni

11	26	9.3	L
12	2	9.1	Ly
	4	9.2	Bb
	6	9.4	R
	7	9.6	R
	7	8.5	Hy
	9	9.6	R
	9	8.5	Hy
	10	9.6	R
	12	9.6	R
	12	8.5	M
	12	8.0	Hu

SV Cygni

Mo.	Day	Est.	Obs.
12	13	8.4	Hy
	13	9.5	R
	14	9.5	R
	15	8.6	Bu
	16	9.2	Ly
	25	8.2	Hy

200715 a

S Aquilae

12	3	10.9	B
	6	11.3	R
	9	11.1	R

200715 b

RW Aquilae

12	3	9.4	B
	6	9.0	R
	7	9.0	R
	9	9.0	R
	10	8.9	R
	12	8.9	R
	13	9.0	R
	14	9.4	R

200812

RU Aquilae

12	12	11.1	B

200938

RS Cygni

11	26	7.8	L
12	2	7.3	Ly
	4	7.3	Bb
	6	7.2	R
	6	8.5	L
	7	7.3	R
	10	7.4	R
	12	8.2	M
	12	7.2	R
	13	7.3	R
	14	7.3	R
	16	8.0	Ma
	16	7.4	Ly

200916

R Sagittae

12	3	8.9	B
	6	9.0	R
	7	9.0	R
	9	8.3	R
	10	8.2	R
	12	8.1	R
	13	8.2	R
	14	8.7	R

201008

R Delphini

12	3	10.9	B

VARIABLE STAR OBSERVATIONS Dec. 1914-Jan. 1915—Continued.

201521

RT Capricorni

Mo.	Day	Est.	Obs.
11	27	7.6	L
12	6	7.4	R

201647

U Cygni

Mo.	Day	Est.	Obs.
12	2	7.3	Ly
	4	7.4	Bu
	6	8.6	L
	6	7.5	R
	7	7.5	Hy
	7	7.5	R
	9	7.6	R
	10	7.6	R
	12	7.7	S
	12	7.6	M
	12	7.1	O
	12	7.6	Bu
	12	7.6	R
	13	7.3	Hy
	13	7.6	R
	14	7.7	R
	16	7.1	O
	16	7.5	Ly
	18	7.9	Bg
	25	7.5	Hy
	25	7.9	E
1	5	7.5	O

202539

RW Cygni

Mo.	Day	Est.	Obs.
12	4	9.2	Bb
	7	8.0	Hy
	12	8.4	M
	12	7.8	O
	13	7.6	Hy
	13	8.4	Bg
	15	9.0	Bu
	16	8.5	Ly
	25	8.5	Hy
	31	8.4	M

202817

Z Delphini

Mo.	Day	Est.	Obs.
12	14	10.8	V

202946

SZ Cygni

Mo.	Day	Est.	Obs.
12	3	9.7	B
	4	9.0	Bb
	6	9.6	R
	7	9.7	R
	9	9.4	R
	10	9.5	R
	12	9.3	M
	12	9.3	R
	12	9.6	Hu
	13	9.7	R
	14	9.7	R
	15	9.8	Bu
	16	9.7	Ly

202954

ST Cygni

Mo.	Day	Est.	Obs.
12	3	10.2	B
	4	10.0	Bb
	12	10.5	Hu
	12	10.3	O
	14	9.8	Y

203847

V Cygni

Mo.	Day	Est.	Obs.
12	4	10.1	Bb
	12	11.3	M
	12	9.6	B
	13	10.9	Bg
	15	10.4	Bu

203816

S Delphini

Mo.	Day	Est.	Obs.
12	12	11.8	Y

204016

T Delphini

Mo.	Day	Est.	Obs.
12	12	12.8	Y

204405

T Aquarii

Mo.	Day	Est.	Obs.
12	18	12.0	B

205017

X Delphini

Mo.	Day	Est.	Obs.
12	16	9.6	B

205923

R Vulpeculae

Mo.	Day	Est.	Obs.
12	4	9.4	Bu
	6	10.1	R
	7	10.2	R
	9	10.2	R
	10	10.2	R
	12	10.3	R
	13	10.4	R
	14	10.5	R
	15	10.0	Bu

210116

RS Capricorni

Mo.	Day	Est.	Obs.
12	6	9.1	R
	7	8.9	R
	9	8.9	R
	10	8.9	R
	12	8.8	R
	13	8.8	R
	14	8.9	R

210112

TW Cygni

Mo.	Day	Est.	Obs.
12	10	12.3	Y

210868

T Cephei

Mo.	Day	Est.	Obs.
12	27	6.1	L
12	2	6.0	Ly
	4	5.5	Bu
	10	6.5	O
	12	6.4	O
	13	6.0	Hy

T Cephei

Mo.	Day	Est.	Obs.
12	15	6.6	O
	15	5.8	Bu
	16	6.2	Ma
	17	6.7	O
	18	6.7	Bg
	18	6.9	O
	18	6.5	Hu
	18	6.0	B
	21	6.9	O
	25	6.5	Hy
1	4	7.4	O
	7	6.7	O

213244

W Cygni

Mo.	Day	Est.	Obs.
11	26	5.5	L
12	6	5.6	L
	6	6.5	R
	7	6.4	R
	9	6.4	R
	10	6.4	R
	12	6.4	R
	13	6.3	R
	14	6.3	R
	15	6.4	L

213678

S Cephei

Mo.	Day	Est.	Obs.
12	18	9.0	Bb
	18	8.6	Hu

213753

RU Cygni

Mo.	Day	Est.	Obs.
12	4	9.3	Bb
	14	9.6	E
	18	9.3	Bg

213843

SS Cygni

Mo.	Day	Est.	Obs.
11	26.2	11.8	L
12	2.5	11.9	Ly
	3.5	12.0	B
	4.5	11.8	E
	4.5	11.9	Ly
	4.7	11.8	Bb
	5.5	11.8	E
	6.2	11.9	L
	11.5	11.9	B
	11.6	11.8	E
	12.5	11.9	B
	12.5	11.8	Hu
	11.5	12.0	M
	13.0	11.9	B
	14.5	12.2	J
	14.5	11.9	E
	14.6	11.6	R
	14.6	12.0	M
	15.2	11.8	L
	15.5	12.2	J
	15.5	11.9	B

SS Cygni

Mo.	Day	Est.	Obs.
12	15.6	12.0	M
	16.5	12.2	J
	16.5	11.9	Hu
	16.5	11.8	B
	16.5	11.8	Ly
	17.5	11.8	B
	17.5	12.3	J
	18.5	11.9	B
	21.4	11.7	E
	21.5	12.2	J
	22.5	11.9	B
	22.5	12.2	J
	23.5	12.2	J
	25.6	9.5	Hy
	26.4	8.2	J
	26.5	8.2	Ma
	26.5	8.6	Ly
	27.4	7.9	J
	27.5	8.8	M
	27.6	8.2	Hy
	28.5	8.6	M
	31.6	8.5	M
1	2.5	8.3	M
	3.4	8.5	O
	4	8.6	S
	4.4	8.4	O
	4.5	8.5	M
	5.5	8.6	O
	7.4	9.5	O
	9.4	10.1	O

213937

RV Cygni

Mo.	Day	Est.	Obs.
11	26	7.6	L
12	4	7.5	Bb
	6	8.0	R
	7	8.2	R
	9	8.0	R
	10	8.0	R
	12	8.0	R
	12	7.2	Hu
	12	7.6	M
	13	8.0	R
	14	7.3	E
	14	8.0	R
	16	7.3	Ma
	16	7.2	Ly
	18	7.5	Bg
	26	7.3	Ly

214024

RR Pegasi

Mo.	Day	Est.	Obs.
12	11	9.1	B
	14	9.2	E

220613

Y Pegasi

Mo.	Day	Est.	Obs.
12	10	9.4	O
	14	10.3	V
	14	10.1	Y
	18	9.6	O

220714

RS Pegasi

Mo.	Day	Est.	Obs.
12	10	9.9	O
	14	10.0	V
	14	10.1	Y
	18	10.4	O

222439

S Lacertae

Mo.	Day	Est.	Obs.
12	12	8.9	Y

222557

δ Cephei

Mo.	Day	Est.	Obs.
12	6.6	4.1	R
	7.6	4.0	R
	9.6	4.0	R
	10.6	4.1	R
	12.6	4.1	R
	13.6	4.0	R
	14.6	4.0	R

223841

R Lacertae

Mo.	Day	Est.	Obs.
12	12.3		Y

225120

S Aquarii

Mo.	Day	Est.	Obs.
12	14	12.5	Y
	18	12.9	B

230110

R Pegasi

Mo.	Day	Est.	Obs.
12	2	7.9	Ly
	4	7.7	Bu
	6	8.4	R
	7	8.4	R
	9	8.4	R
	10	8.4	R
	10	7.8	O
	12	7.7	Bu
	12	8.4	Hy
	12	8.4	R
	12	7.9	O
	12	8.0	Pi
	13	8.3	R
	14	8.3	R
	14	8.1	O
	16	8.4	Ma
	16	7.6	Hu
	17	8.1	O
	21	8.4	O
1	3	8.7	O
	5	8.7	O
	7	8.7	O

230759

V Cassiop.

Mo.	Day	Est.	Obs.
12	14	12.0	Y
	21	11.2	E

231425

W Pegasi

Mo.	Day	Est.	Obs.
12	16	11.0	Hu

VARIABLE STAR OBSERVATIONS Dec. 1914-Jan. 1915—Continued.

231508 S Pegasi				233335 ST Androm.				*233815* R Aquarii				R Aquarii				235525 Z Pegasi			
Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs	Mo.	Day	Est.	Obs.
12	12	11.5	B	12	3	9.7	Ly	12	2	9.3	Ly	12	12	9.6	R	12	11	9.9	E
					4	10.4	Bu		6	9.3	R		13	9.7	R		15	9.7	V
					12	10.0	S		7	9.6	R		13	9.2	Hy				
					12	10.2	Bg		7	9.2	Hy		14	9.6	R		235939		
					16	10.3	O		9	9.4	R		16	9.5	Ly		SV Androm.		
					21	10.0	E		10	9.5	R		235350				12	12	11.6	Hu
													R Cassiop.						
												12	11	8.1	E				

No. of observations 893; No. of stars observed 145; No. of observers 20.

The variable *021403 o* Ceti is now visible to the naked eye, and we have a good opportunity of observing and recording a reliable maximum. To assist in its observation the following table of magnitudes of stars in the region of the variable is given.

In Pisces: α 3.9, ξ 4.8.

In Cetus: α 2.8, γ 3.6, δ 4.0. ξ^2 4.3. ξ^1 4.5, μ 4.6, λ 4.7, ρ^3 4.9.

In Eridanus; γ 3.2, δ 3.7, ϵ 3.8.

The list of stellar magnitudes will enable anyone to observe the approaching maximum of this wonderful variable. It is hoped that many who are not members of the Association will avail themselves of this opportunity of making practical and valuable observations.

Members with large telescopes are requested to observe the following variables, which are now faint:

004132 RW Andromedae
011208 S Piscium
023133 R Trianguli
030514 U Arietis
042215 W Tauri
042209 R Tauri
042309 S Tauri
045307 R Orionis
052036 W Aurigae
053531 U Aurigae
054974 V Camelop.
063159 U Lyncis
063558 S Lyncis
073723 S Geminorum

The Secretary again calls attention to those who are delinquent in sending in their reports. Lists must be in the Secretary's hands by the 4th or 5th of each month. Will members please comply with this request.

More volunteers are needed for the Nova search work that we have taken up in accordance with the plan outlined by Mr. Leon Campbell.

The following members contributed to this report:

Messrs. Barbour, Bolfing, Bouton, Burbeck, Eaton, Hay, Hunter, Jacobs, Lacchini, Lindsley, Mach, McAteer, Mundt, Olcott, Pickering, Richter, Spinney, Vrooman, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Jan. 10, 1915.

COMMUNICATIONS.

The Nova Search Section of the S. P. A. and its Work.—I have been keenly interested in reading Mr. Leon Campbell's paper in the October, 1914, issue of POPULAR ASTRONOMY, entitled "A Systematic Search for Bright Novae." I wish to express my hearty appreciation of his plan and to second it as a valuable means for amateurs, particularly those with limited equipment, to make their efforts worth while. But I should like to call attention to an organization which Mr. Campbell fails to mention, when he states that "There are at present two large scientific bodies, the American Association of Variable Star Observers..... and the Variable Star Section of the British Astronomical Association.....which are doing valuable work in the study of variable stars, both of the brighter and fainter classes. To these organizations it seems best to look for the work of a systematic search for bright novae." I refer to the Nova Search Section of the Society for Practical Astronomy, of which Mr. Nels Bruseth, of Los Angeles, Cal., is Director. Mr. W. T. Olcott (*P. A.* for November, 1914, p. 605, "Practical Work for Observers without Telescopic Equipment") has remarked that this Section "is already engaged in this interesting and valuable work"; but I beg to describe the purpose and interests of the body in more detail.

I first announced in POPULAR ASTRONOMY the formation of the Nova Search Section of the S. P. A. in the December, 1913, number, p. 658 (*q.v.*). In the January and February, 1914, issue of the *Monthly Register* of the S.P.A. there appeared a note by Mr. Bruseth, the Director, entitled "Object and Plans of the Nova Search Section." Space does not permit me to quote the substance of that note here, but if anyone will turn to it he will find that the plans of the Section, as outlined by Mr. Bruseth, are practically identical with those suggested by Mr. Campbell in *P. A.* for October, 1914. The N. S. S. of the S. P. A. commenced its active work in August, 1913, although it was not officially established as a Section of the Society until the following November. A report was submitted in the July and August, 1914, *Monthly Register*, in which Mr. Bruseth wrote: "No nova has been found, but several of the observers have become so familiar with their areas that they could have easily discovered a new object if it had reached a naked-eye magnitude." The official list of members of the section, dated 1914 August 18, includes the names of twenty S. P. A. members—eighteen active observers (to whom definite areas for search were assigned by the Director) and two "occasional" observers. As far as my knowledge of the matter extends, the Nova Search Section was the first body expressly organized for the systematic search of new stars. The idea of such a Section in the S.P.A. was entirely original with Mr. Bruseth, and to him all the credit for the development and direction of the work of the Section is due. In a paper which will appear in an early issue of the *Monthly Register*, Mr. Bruseth writes in part as follows:

"It is interesting to note that nova search work is gaining in popularity, and that it is receiving recognition as a valuable branch of astronomical research. When it was first proposed by Mr. Alan P. C. Craig, of Corona, Cal., Director of the Auroræ, Zodiacal Light and Gegenschein Section of the S. P. A., and offered in a special Section of the Society, it did not meet with the same interest as when proposed by Mr. Leon Campbell. Thinking it worth while and a good plan, I sent out letters to members calling for volunteers, and got a very favorable response. Eventually the Section was organized and brought into working order. Its "Object and Plans"

were given in the January and February, 1914, number of the *M. R.*, and, though not so extensive, are nearly the same as those given by Mr. Campbell. I shall be pleased to hear from new and other members of the S. P. A. who wish to take up the work. We should be grateful to Mr. Campbell for the boost he has given the work."

I should like to add, in calling attention again to the Nova Search Section and its work, that the Society for Practical Astronomy will gladly welcome as members all observers who may desire to take up systematically this or any other branch of observation. Since the observations requisite for the search of new or temporary stars, as planned by the Director of the Nova Search Section, can be pursued almost entirely with no more extensive an equipment than a pair of opera glasses and a good star chart, such occupation should appeal especially to those who are interested in the promotion of astronomy, but who have not the use of a telescope; nova search work does in fact afford valuable occupation for the man entirely devoid of instrumental equipment altogether, in a way in which few other lines of observation can. The S. P. A. now has a membership of nearly ninety active astronomical workers in all parts of the world, and it offers assistance and coöperation in nine Observing Sections. In closing, I wish to thank Mr. Campbell for bringing the value of nova search work so forcefully to the attention of amateur and, as he expresses it, semi-professional observers, and to say that I shall be pleased to hear from anybody interested in this or any other kind of observation embraced by the Observing Sections of the S. P. A.

FREDERICK C. LEONARD,
President of the S.P.A

1338 Madison Park, Chicago, Ill.,
1914 December 29.

GENERAL NOTES.

Dr. W. W. Campbell, director of the Lick Observatory has been elected president of the American Association for the Advancement of Science for the meetings to be held this year in San Francisco and Columbus. The San Francisco meeting will be held from August 2 to 7 and the Columbus meeting from Dec. 27, 1915 to Jan. 1, 1916.

Professor A. O. Leuschner, of the University of California, was elected vice-president for Section A: Astronomy and Mathematics.

Professor E. W. Brown of Yale University was elected president of the American Mathematical Society at the New York meeting Jan. 1 and 2.

Dr. Frank Schlesinger gave the vice-presidential address to Section A. of the A. A. A. S. at the Philadelphia meeting, on the subject "The Object of Astronomical and Mathematical Research."

Astronomical Telegrams.—The international service of telegrams from Kiel having been interrupted by the war, the management of the "Zentral-stelle" has been passed over to Professor Elis Strömgren, Copenhagen Observatory. (*Science* Jan. 15, 1915.)

The Theory of the Moon's Motion.—A brief review of an address by Professor E. W. Brown before the sub-section of cosmical physics at the Australian meeting of the British Association is given in the December number of *The American Journal of Science.* In the course of the address the speaker said that the principal deviations of the moon from its calculated path "consist first of the great inequality discovered by Simon Newcomb having a period of some 270 years and an amplitude of about 12 seconds of arc. This is a deviation of the moon in front of and behind its theoretical position. Superposed on this are smaller deviations which appear to have a main period of between 60 and 70 years and a coefficient of 3 or 4 seconds. But it is pointed out that this is not a periodic change in the proper sense, for it has been found impossible to analyze it. It is these deviations which have formed the subject of a number of hypotheses. It appears now to be fairly certain that they cannot be accounted for by any gravitational cause.

"Professor Brown rejects many of the hypotheses which at first sight seem possible; for example, a planet inside the orbit of Mercury or a swarm of small bodies near the sun. Bottlinger's hypothesis of the shading of gravitation by interposing matter is attractive, but the curve he gets does not fit the observed deviations and according to theory it should not be able to account for them. The motion of the magnetic field of the earth has also been mentioned," but it is to be rejected because this hypothesis would require changes in other parts of the moon's orbit which cannot be admitted.

For the ellipticity of the earth Professor Brown finds in three different ways the number 1/294, which agrees with Clarke's value obtained from geodetic measures (1/293.5) but differs from Helmert's determination (1/298), and he believes that the evidence for 1/294 is sufficiently strong to require its adoption for astronomical purposes.

He urges that at some governmental observatory in the southern hemisphere the Harvard method of obtaining the position of the moon by photography be systematically employed.

An interesting statement is made as to the degree of accuracy of the Newtonian law. From the agreement of the theoretical and observed motion of the moon's perigee it is concluded that the index which the inverse square law contains does not differ from 2 by a fraction so great as 1/400,000,000.

The Civil Date of the Autumnal Equinox.—In general September 22 is the civil date which is associated with the time of the autumnal equinox. A moment's thought will show that the interval between two autumnal equinoxes must be 365 days and about six hours, that is to say the exact length of the year. If therefore the instant of the autumnal equinox in a given year, should be noon on September 22, in the following year it would necessarily be approximately six P. M., on September 22, provided it were not a leap year. Therefore starting with the earliest possible moment for the autumnal equinox in a given year, in four or five years it would certainly be advanced to September 23, and in four years more to September 24 and so on were it not for the leap years which intervene. But the addition of the extra day in February prevents the time of the autumnal equinox from advancing beyond September 23 except at rare intervals. One of these occurred in 1903, when the time of autumnal equinox was 1 A. M. on September 24. This resulted from the fact that 1900 was not considered a leap year.

Obviously the same conditions obtain in the case of the vernal equinox which recurs at the same interval as the autumnal equinox does.

Astronomical Fellowships of the Nantucket Maria Mitchell Association.—The Quadrennial Fellowship of $1000 for the year June 15, 1915, to June 15, 1916, has been duly awarded to Miss Margaret Harwood, A. B., Radcliffe College, 1907, whose three years of continuous efficiency as Astronomical Fellow of the Association entitle her to this distinction. This Fellowship, when earned, permits the fellow to avail herself of the entire year for study and research in an Observatory of her own selection. Miss Harwood has elected to devote her "Quadrennial" to the University of California.

In accordance with the provision of the circular issued December, 1913, the second Fellowship of $500 was awarded a year in advance, in order that the successful candidate might prepare herself for the special work undertaken by the Maria Mitchell Observatory.

Miss Susan Raymond, A. B., Smith College, 1913, has received the appointment. Miss Raymond already has commenced her preparation, occupying a portion of her summer vacation this year at Harvard Observatory, where half of her Fellowship year will be spent. During a part of the summer she has been at the Nantucket Maria Mitchell Observatory, with Miss Harwood. This autumn (1914) she will resume her duties at Smith College, and June 15, 1915, her work at the Nantucket Observatory will begin.

The next circular offering the $1000 Fellowship is due to be issued October, 1915, for the year June 15, 1916, to June 15, 1917.

COMMITTEE
ANNIE J. CANNON, A.M., *Chairman*, Harvard College Observatory.
PROF. MARY W. WHITNEY,
Director Emeritus of Vassar College Observatory.
PROF. ANNE S. YOUNG, PH. D.,
Director of Mt. Holyoke College Observatory.
DR. EDWARD C. PICKERING, Director of Harvard College Observatory.
ELIZABETH R. COFFIN, A.B., Vassar College, 1870.
FLORENCE M. CUSHING, A.B., Vassar College, 1874.
LYDIA S. HINCHMAN, *Secretary*, 3635 Chestnut Street, Philadelphia.

Absorption of Light in Space.—In *Monthly Notices* of the Royal Astronomical Society, Vol. LXXV, p. 4, Mr. H. S. Jones, of Greenwich, gives an extensive discussion of the question of the absorption of light in space, reaching the conclusion that "there is a small but appreciable loss of light in space due to selective scattering, the difference between the photographic and visual losses in a distance of ten parsecs (a parsec is the distance of a star whose parallax is 1″) being $+0^m.00473 \pm 0.00035$. Assuming that the scattering is in accordance with Rayleigh's law, this is due to a loss for the photographic rays of $0^m.0080$ and for the visual of $0^m.0033$.

"There is an effect of the absolute magnitude upon the colour index, the increase of the colour index due to unit increase in absolute magnitude being $+0^m.0336 \pm 0.0053$. This means that, on the average, considering stars of the same spectral type and at the same distance, the more luminous ones appear to be bluer."

The Observer's Handbook for 1915.—This useful handbook is issued by the Royal Astronomical Society of Canada. It is a little book of 76 pages giving the principal astronomical phenomena which can be predicted for the year, ephemerides of the sun and moon, short lists of the brighter double and variable stars, a list of 272 stars and five nebulæ whose radial velocities have been determined, charts and descriptions of the constellations and a list of the comets of 1914.

Nova Geminorum.—A letter received at this observatory from Professor Walter S. Adams, of the Mount Wilson Solar Observatory, contains the following statement:—

"A photograph of the spectrum of Nova Geminorum, No. 2, taken on November 16, shows the complete disappearance of the chief nebular line at λ5007 and the associated line at λ 4364. The second nebular line at λ 4960 is still strong. Photographs of the spectrum taken in February and May showed all the nebular lines to be present. So far as I know this is the first time that a marked difference in behavior of the first and second nebular lines has been observed."

EDWARD C. PICKERING,
Director.

Harvard College Observatory, Bulletin 572.
Cambridge, Mass., U.S.A., December 10, 1914.

The Astrophysical Observatory of the Smithsonian Institution.—Director Abbot's annual report covers the work of the Astrophysical Observatory for the year ending June 30, 1914. He reports that progress has been made in the measurement of the effects produced by atmospheric water vapor on solar and terrestrial radiation. New apparatus has been devised for measuring sky radiation. Special pyrheliometers have been constructed and caused to record solar radiation with considerable success at great altitudes when attached to free balloons. The results obtained tend to confirm the adopted value of the solar constant of radiation. Further results from balloon pyrheliometry are expected. A tower telescope has been erected and put in operation on Mount Wilson. By means of it the variability of the sun has been independently confirmed, for it appears that changes of the distribution of radiation over the sun's disk occur in correlation with the changes of the sun's total radiation.

Resumè of Sunspot Observations at Mt. Holyoke College, 1914.

Mo.	No. of Obs.	Days without	North of Eq. No. Group	North of Eq. Aver. Lat.	South of Eq. No. Group	South of Eq. Aver. Lat.	Av. No. at each obs.	New groups
				°		°		
Jan.	10	10	0	—	0	—	0	0
Feb.	16	12	0	—	1	−13.0	0.25	1
Mar.	14	12	1	+42.5	0	—	0.14	1
Apr.	17	3	3	25.9	2	23.1	.94	5
May	20	15	3	24.9	0	—	.35	1
June	13	0	1	29.0	3	19.8	.77	4
July	1	1	0	—	0	—	.0	0
Aug.	5	2	1	20.0	0	—	.60	1
Sept.	14	1	2	19.9	2	25.9	1.78	4
Oct.	22	9	4	22.3	1	27.7	.82	4
Nov.	19	1	4	21.97	3	21.9	1.42	7
Dec.	11	0	3	22.3	4	21.7	2.00	6
Total	162	66	22		16			34

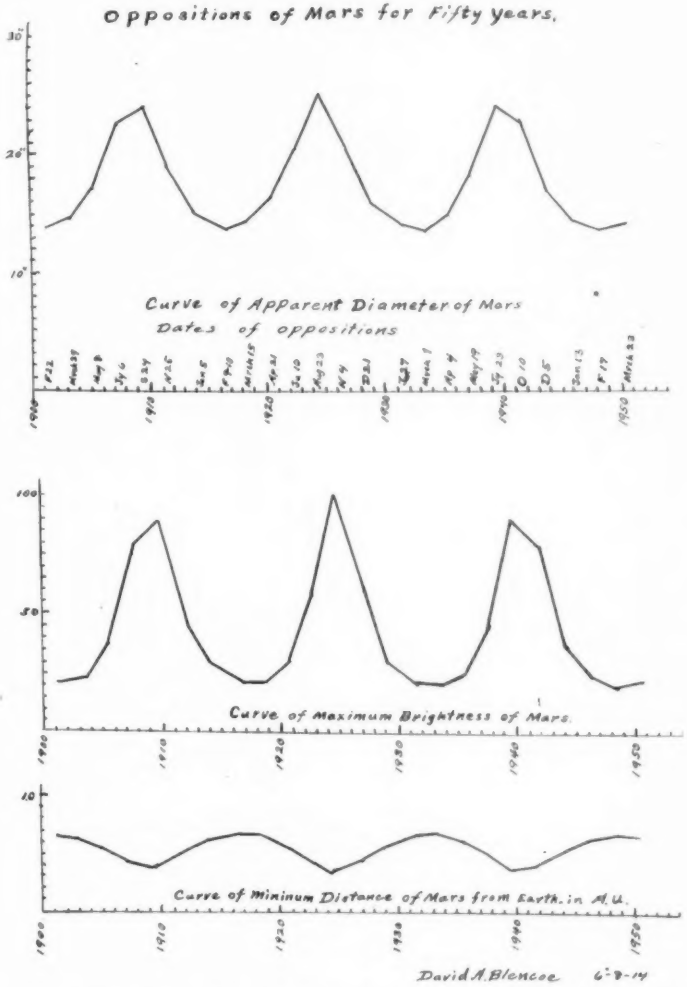
Average number at each observation .83
Average latitude of spots north of equator +24°.05
Average latitude of spots south of equator −21 .80

Note group in March in exceptionally high atitude.

ANNA D. LEWIS.

The John Payson Williston Observatory
Dec. 22, 1914.

Oppositions of Mars for Fifty Years.—Mr. David A. Blencoe has graphically represented in the following chart the variations of Mars at different oppositions. The upper curve represents the maximum apparent diameter



of the planet, the middle curve its maximum brightness and the lower curve the minimum distance of the planet from the earth at the different epochs of opposition These lines are not true curves but are simply lines connecting the successive maxima, in the two cases, and the successive minima, in the other case, of the true curves of the functions named.

Lord Rosse's Telescope, the famous 6-foot reflector which has been depicted in most books on astronomy for the last 70 years as the largest telescope in the world, has been presented to the Science Museum at South Kensington. It has been little used for many years. (*Scientific American*, Dec. 19, 1914.)

An Australian Mary and Martha.—Mary enquires, "Are you coming to the discussion on the ionization of gases?" Martha snaps, "No! *I've* got to stop at home and attend to the ironization of shirts." (From an Oxford Notebook. *The Observatory.*)

Publications Received.

Decker, F. F. The symmetric function tables of the fifteenthic, including an historical summary of symmetric functions as relating to symmetric function tables. Carnegie Institution, Washington, D. C., 1910.

Lehmer, D. N., Factor table for the first ten millions. Carnegie Institution, Washington, D. C., 1909.

Bjerknes, V., Dynamic meteorology and hydrography, plates. Carnegie Institution. Pub. No. 88, Washington, D.C., 1911.

Lehmer, D. N., List of prime numbers from 1 to 10,006,721. Carnegie Institution, Pub. No. 165, Washington, D. C., 1914.

Aitken, R. G., Measures of double stars. Pub. Lick Observatory, Vol. XII, 1914.

Doolittle, C. L., Results of observations with the Wharton Reflex Zenith Tube and the zenith telescope of the Flower Astronomical Observatory 1906-1911. Pub. Univ. Pennsylvania, Astronomical Series, Vol. III, Pt. II.

Reed, Wm. G., Meteorology at the Lick Observatory.

Harper, W. E., Orbit of σ Geminorum. Pub. Dominion Observatory, Ottawa. Vol. 1, No. 9, 1914.

Cannon, J. B., Orbit of *b* Persei. Pub. Dominion Observatory, Ottawa, Vol. 1, No. 10. 1914.

Harper, W. E., Orbits of the spectroscopic components of *d* Boötis, Pub. Dominion Observatory, Ottawa, Vol. 1, No. 11, 1914.

Harper, W. E., Radial Velocity of ρ Leonis. Pub. Dominion Observatory, Ottawa, Vol. 1, No. 12, 1914.

Cannon, J. B., Orbit of ξ Persei from the H and K lines. Pub. Dominion Observatory, Ottawa, Vol. 1, No. 13, 1914.

St. John, C. E., On the distribution of the elements in the solar atmosphere as given by flash spectra. Contributions from the Mount Wilson Solar Observatory No. 88.

Shapley, H., Intermediate degrees of darkening at the limit of stellar disks, with an application to the orbit of Algol. Contrib. Mount Wilson Solar Observatory, No. 86.

Adams, W. S., and F. G. Pease, The spectra of four of the temporary stars. Contrib. Mount Wilson Solar Observatory, No. 87.

Adams, W. S., and Arnold Kohlschütter, Some spectral criteria for the determination of absolute stellar magnitudes. Contrib. Mount Wilson Solar Observatory, No. 89.

Pickering, E. C., Color equation of various star catalogues. Annals Harvard College Observatory, Vol. 76, No. 2.

Cannon, Annie J., Spectra having bright lines. Annals Harvard College Observatory, Vol. 76. No. 3.

Pickering, E. C., Stars having peculiar spectra. H. C. O. Circular 184.

Leavitt, Henrietta S., The north polar sequence. Annals Harvard College Observatory, Vol. 71, No. 3.